

Hydrology in Croatia, 1995 – 1998

Report to the International Association of Hydrological Sciences of the International Union of Geodesy and Geophysics

In the period from 1995 to 1998 hydrological analyses and studies in Croatia have mostly been carried out in the Institute of Hydrology and Meteorology in Zagreb, the University of Split, the Faculty of Civil Engineering, the Croatian Waters and the Energy Institute Ltd.

Besides the institutions mentioned, hydrology has also been developed and promoted in a very active Croatian Hydrological Association (CHA) whose president is Prof. O. Bonacci and secretary D. Trninić. During the period from 1994 to 1998 Croatian Hydrological Association, Zagreb organized two Round Tables: *The Role of Hydrology in the Structure of Croatian Economy* (Zagreb, April 1995, Proceedings: 13 papers; 16 authors and coauthors; 116 pages) and *Water in Croatian Islands* (Hvar, September/October, 1998, Proceedings: 23 papers; 33 authors and coauthors; 244 pages). In the organization of Croatian Hydrological Association the promotion of a hydrological monograph was also held (Zagreb, 1995) as well as three scientific lectures (one in Varaždin in 1995 and two in Zagreb in 1997) and two presentations of hydrometric equipment. In 1995 Croatian Hydrological Association was a coorganizer of the *Scientific Meeting: Agriculture and Water Management* (Bizovačke Toplice, November 1994, Proceedings: 46 papers, 557 pages) and the *1st Croatian Conference on Waters* (Dubrovnik, May, 1995, Proceedings 1: 56 papers, 561 pages, Proceedings 2: 56 papers, 535 pages).

The activity of the Board of CHA in organizing the *XIXth Conference of the Danube Countries on Hydrological Forecasting and Hydrological Bases of Water Management* was particularly important with the main organizers: Croatian National Committee for Collaboration with International Hydrological Programme of UNESCO and the coorganizer: the Faculty of Economics of the University Josip Juraj Strossmayer in Osijek (Osijek, June, 1998, Proceedings: 137 papers, 1129 pages).

From 1995 to 1998 Croatian hydrologists participated at international scientific meetings and conferences with in total 46 papers. Here only the books, the chapters in the books and the articles published in scientific-professional journals are briefly described and stated at the end of the report. The main part of the studies described deals with the hydrology of karst which covers about one half of the territory of Croatia and the water runoffs in karst are very interesting from hydrological point of view, while other papers deal with other hydrological subjects: high waters, the relation: precipitation – runoff, small waters, biological minimum, sustainable development and the development of hydrology.

Bonacci (1995 a) hydrologically explains the water inflows into the Vransko Lake on the island of Cres, which represents a karst phenomenon. He defines the approximate acreage of the catchment area and analyzes the oscillations of water in the lake connecting them with precipitation and presents primarily hydrologic analysis which is only a first step in an attempt to explain this exceptionally com-

plex and interesting karst phenomenon. Bonacci (1995 b) describes hydrological problems for a hydro-electric power plant which will exclusively use water from a karst underground storage basin which will be built in the vicinity of the abundant karst spring Ombla near Dubrovnik in Croatia. This paper presents the results obtained by hydrogeologic, hydrologic and hydraulic investigations related to the principles of ground water circulation in the karst. Characteristic features of the discharge curves made the identification of the position and the dimensions of the main karst conduits possible. In the paper for the Croatian Academy of Sciences and Arts Bonacci (1995 c) continues the earlier hydrological investigations of Vransko Lake in the island of Cres by new cognitions on the basis of considerations of hydrological, meteorological and hydrogeological investigations carried out.

Gereš et al. (1995) show the surface and ground water balance in Croatia. The review is given of water quality and water protection, with the data on waste water. The aim is to integrate the information on water management system with GIS.

Patrčević (1995) show the approach and hydrologic methods used as well as the results of hydrologic research on the Chiffe torrential waterflow in Algeria. The flood wave, resulting from an intensive cyclonic disturbance, produced extensive damage at the building site at the Chiffe derivation. Hydrologic research was carried out to establish the amount of water that caused the flood.

The catastrophic high-water levels registered in Istrian drainage basins in October 1993 are described by Rubinić (1995). It has been established through the analysis of this flood that the priority on the future flood protection policy should be given to the construction of multipurpose reservoirs. Žugaj (1995 a) describes the regional analysis of typical hydrological parameters of watercourses in the region of Dinaric karst in Croatia, which regularly dry out every year.

Croatian Hydrological Association published a monograph on regional analysis in the karst of Croatia (Žugaj, 1995 b). In the monograph the correlations of characteristic parameters for the functions of two and more variables are examined. The investigations were carried out for medium, maximum and minimum discharges. The results obtained for the catchment areas of Croatian karst were compared with the results of regional analyses carried out for other karst regions.

For the manual being published regularly once a year more than 300 Croatian expressions for different hydrological terms with synonyms have been prepared (Žugaj, 1995 c).

The paper (Bonacci, 1996 a) explains numerous aspects which influence the characteristics of precipitation transformation process in the runoff on the lowland grounds. Models which take into account important influence of retaining large quantities of water in the catchment area, slow runoff from the catchment area, long-term concentration period dominant vertical component as well as low values of a runoff coefficient are given. In the other paper (Bonacci, 1996 b) analyzes the idea of sustainable development, emphasizing the water management aspect. Numerous definitions are given, as well as various perceptions of the idea of sustainable development which finally lead to the conclusion that man has understood that development consurvival by him does not guarantee this survival on Earth or survival of the Earth as a whole. The continuity of the process of globalization and diversity in the biosphere and the technosphere is presented. In the next paper (1997 a) Bonacci presents the theoretical principles and gives details of three most

commonly used methods as well as a new one which is considered to be both theoretically and practically the most correct. The last section of the paper presents the results of the latest research in hillslope runoff process obtained on the pilot watershed of Panola in the USA. Bonacci and Roje-Bonacci (1997 b) analyze the inflow of sea water into the karst springs on the coast describing the spring Bulaž in Istria in Croatia as an interesting example.

A chapter in the book on water in karst (Bonacci and Plantić, 1997 c) describes very good results of runoff simulation on the mathematical model SSARR applied on the catchment area of Drežničko Polje in Gorski Kotar in Croatia.

In their papers Bonacci and Roje-Bonacci (1997 d and 1997 e) present primarily the hydrological aspects of determining the biological minimum of the Žrnovnica and Jadro rivers near Split in Croatia. In accordance with the variable hydrological regime, the variable values of permissible water abstraction have been determined.

In the paper of Trninić (1997) the hydrographs of large hydrographs of the river Sava in the profile Zagreb (Croatia) being recorded during the last 40 years. The volumes of the hydrographs beyond the repair discharge have been particularly analysed.

Žugaj (1997) illustrates, on typical hydrographs, the procedure of hydrograph separation between the basic (subsurface and underground) inflow and the direct (surface) inflow. Determining of the hydrograph recession time is considered, in particular according to the Linsley formula, in which considerable deviations of the magnitude of the exponent n have been determined for karst catchment areas compared to the original value.

The paper (Bonacci, 1998 a) discusses the complex interdependence of development of cities and the growing demand for water in order to ensure their further development. The paper gives a review of the water problems in the city of Zagreb, with particular emphasis on the unsolved relations between the Sava river and the development of the city. In the next paper Bonacci et al. (1998 b) define the ecologically acceptable flows in Žrnovnica river (Split, Croatia). The final objective of the defined values of the biological minimum is to preserve the nutrition chain in the Žrnovnica river and to secure normal conditions for the growth of rare and endangered fish species, the endemic trout (*Salmothymus obtusirostris*) in the specific case.

The phenomenon of the limited capacity of effluence, which appears at some karst springs is presented in the paper (Bonacci, 1998 c). For the purpose of explaining this phenomenon, the theoretical aspect of water effluence from the karst springs is described.

In the paper (Rubinić and Ožanić, 1998) the optimization of drinking water management in a specific island environment in the Ponikve karst valley on Krk island (Croatia) is presented. Authors show how well-conceived artificial projects – such as the small water storage facility in karst terrain on Krk – are capable of increasing water-supply quantities in highly sensitive hydrological systems.

In the last paper (Žugaj, 1998) depicts main events that contributed to the development of hydrology as applied science in the course of the history of mankind. The author shows how hydrological knowledge and understanding of water regime properties developed in parallel with breakthroughs in other sciences, depending on the need of humans to either use water or to protect themselves from its power.

List of publications

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- Bonacci, O. (1995 b): Ground Water Behaviour in Karst: Example of the Ombla Spring (Croatia), *Journal of Hydrology* 165, 113–134.
- Bonacci, O. (1995 c): Investigations in Karst Hydrology of Croatia: The Vrana Lake on the Island Cres, *Acta Geologica, HAZU*, Vol. 25(1), 1–15.
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Doctoral dissertations

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- Ožanić, N. (1996): Hydrological Model of Vrana Lake Functioning on Cres Island, University of Split, Faculty of Civil Engineering, Zagreb.

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