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Role of Hydrology in Water Resources Management

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Abstract – The importance of hydrology is increasing because of the global growth of water needs and the rise of water scarcity, which together cause greater risk and unreliability in water resources management. The basic task of hydrology, which is fundamental for water resources management, is the accurate definition and control of the water balance for different space and time increments.

The water balance equation is simple, but until now there are many unsolved problems surrounding it, such as: the definition of catchment boundaries and areas, the accuracy of point precipitation measurement and the assessment of areal precipitation, the accuracy of actual areal évapotranspiration etc. Modern computer and numerically oriented hydrology tries to use most new scientific approaches, methods and technologies. Due to the influence of university education and papers published in leading international scientific journals, young scientists, in particular, believe that this is the sole way to advance knowledge.

Experienced and practically oriented hydrologists do not always share their enthusiasm. Hydrology has to be loyal to its basic principles and roots, in order to be able to answer the complex challenges of water resources management which will come in the future. As water management is an interdisciplinary task, hydrology should be more connected with the other scientific disciplines and professions involved. Hydrology urgently needs close co-operation with many other human activities, especially those concerned with environmental issues.

Keywords: Eco Hydrology; Hydrological Cycle; Hydrology; Water Balance; Water Resources Management

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INTRODUCTION

UNESCO and WMO give the following definitions of hydrology: (a) Science that deals with waters above and below the land surface of the Earth, their occurrence, circulation and distribution, both in time and space, their biological, chemical and physical properties, their reaction with the environment, including their relation to living beings; (b) Science that deals with the processes governing the depletion and replenishment of water resources of the land areas of the Earth, and treats the various phases of the hydrological cycle.

The new problems arise and the science is extended. Its scope is limited to considerably less than the entire field of water science". For Bras (2010) hydrology is the study of water in all its forms and from all its origins to all its destinations on the Earth. The hydrological umbrella would include waterquality issues. Hydrology, the science of water, as one of the geosciences has a natural place alongside geology, oceanography, meteorology etc. For Falkenmark & Chapman (2015), hydrology in its modern sense is a young science, focusing on various phenomena related to the hydrological cycle. The continuity of this cycle adds new perspectives to the study of issues related to environment and development.

From the definitions and concepts it can be concluded that hydrology has a dual role as a scientific discipline and as a basis for informed decision-making on important practical problems (Dooge, 2015). It should be stressed that hydrology has, at the same time, very deep scientific interests and tasks and an extremely important role in practice. For hydrologists the main dilemma is how to develop a true hydrological science and at the same time to provide a reliable basis for decision making in water resources management. This is really an old and omnipresent dilemma between theory and practice.

Due to the shortage of water and its crucial importance for life on Earth, the gap between theory and practice in hydrology is especially risky and should be overcome. On the one hand hydrology has to develop theoretically and on the other it should react promptly in practical terms. This is probably the reason why hydrology is so open to many other sciences, new technologies, methods, models and initiatives. Hydrology tries to solve numerous practical problems by forming different branches and/or specialist fields such as: engineering hydrology, urban hydrology, snow hydrology, karst hydrology, hillslope hydrology, surface water hydrology, regional hydrology, comparative hydrology and in the last 10 years, ecohydrology.

Kundzewicz (2012) states that despite recent activity in the area of ecohydrology, it does not necessarily have the same meaning to everyone. A number of competing definitions raise sensitivities and controversies among scientists and practitioners. For Zalewski (2010) ecohydrology is the study of the functional interrelation between hydrology and biota at the catchment scale. According to Zalewski, ecohydrology is a new approach to achieve sustainable management of water. Nuttle (2012) states that this broadly accepted definition is controversial. Eagleson's (2012) perception of ecohydrology is different. For him ecosystems are complex, evolving structures whose characteristics and properties depend on many interrelated links between climate, soil and vegetation. According to him ecohydrology examines in which way the physical characteristics of trees and their forest communities are related at equilibrium with the climate and soils in which they are found.

One of the main reasons for the unsatisfactory state of water management issues is the complexity of the time and space scale of the processes involved in the hydrological cycle. Hydrology can consist of very small and very fast processes, whose causes may appear in limited areas over short periods, but the consequences are felt in larger areas during prolonged periods. These small scale processes exist alongside global long-lasting geological and other processes which influence the local hydrological conditions.

The enlarged scope of hydrology brings increased complexity and interactions with allied sciences, which makes hydrology extremely dynamic and open to many new and modern initiatives. A critical difficulty for the future of water resources management is the integration of different and individual approaches and solutions coming from different scientific disciplines. Hydrology, with its scientific and engineering capabilities and experiences, is the most appropriate for helping this process. Maybe hydrology is not a completely detenninistic science (as some scientists think) but its leading role in water resources management is beyond question. However, there are a number of problems which need to be solved.

CRITICAL TASKS OF HYDROLOGY

The hydrological cycle is a central concept of hydrology. Water within it is continually flowing, but the problem is that the flux through the hydrological cycle is not distributed evenly in time and space. This uneven distribution is one of the main concerns of hydrology and of water resources management, linking one to the other with strong bonds. The basic role of hydrology, which is fundamental for water resources management, is the accurate definition and understanding of the water balance for different space and time increments. The water balance equation is, of course, simple. The problem is in its application, because it has a number of aspects which are not fully understood and because some basic variables and parameters are poorly measured and/or not estimated accurately. The improvement of this situation is a critical task for hydrologists and, at the same time, for water resources managers. Three matters demand attention in particular .

In many landscapes, for example in karst and flatlands, this is a difficult and complex task, which is very often unsolved. Without this information it is not possible, efficiently and exactly, to make a water balance, to protect water from pollution, to manage the water resources, to use hydrological models etc. Generally speaking, the catchment area defined from surface morphology, i.e. the topographic catchment, rarely corresponds exactly to the hydrological drainage basin. The differences between the topographic and hydrological catchments in karst terrain, are, as a rule, so large that data about the topographic catchment cannot be used without some explanation. A similar situation exists for flatlands and for some mountain streams. It should be stressed that human interventions, especially the construction of dams and reservoirs, can introduce definite and hardly determined changes of catchment boundaries. Natural and man-made processes cause changes of catchment area at different time and space scales. The catchment area forms the best planning units for land, water, and ecosystem management. Most catchment areas incorporate state and local government boundaries, and these different administrative units make policy forming for water resources management extremely difficult. The starting point for most hydrological determinations related to the water balance is knowledge of the amount and distribution of precipitation with respect to time and space. Precipitation is routinely measured throughout the world, but obtaining error-free knowledge of its spatial and temporal distribution is hampered by the diversity of observing standards and the erratic pattern of observing networks.

Most important is the systematic error of point precipitation measurement and it is astonishing that this systematic error is not taken into account by most meteorological services. For the purposes of the Hydrological Atlas of Switzerland, precipitation depths were corrected across the country. On average precipitation values were increased by up to 14%. The corrections range from 4% for flatlands, to 30% for alpine areas with a significant amount of snow. Where water balances are still computed with uncorrected precipitation values, neither évapotranspiration nor groundwater volumes can be properly assessed.

Evapotranspiration is the combined consumptive-evaporative process by which water is released to the atmosphere through vegetation, soil and from a free water surface. It is the concurrent occurrence of evaporation and transpiration that influences each other; e.g. soil evaporation is reduced by the occurrence of transpiration. Actual évapotranspiration can be defined as the évapotranspiration from a vegetative cover under natural or given conditions for the catchment or region when the supply of water to plants is limited by the availability of moisture. Engineers and/or hydrologist are generally interested in the water-mass balance and not in the consumption of an individual plant. As évapotranspiration is a complicated process there are several approaches to its assessment. According to the sphere of interest and the related discipline it can be analysed through: (a) Plant physiology (transpiration ratios and pot tests); (b) Hydrology (water budget applied to catchments or regions); (c) Climatology (use of atmometers and pans); (d) Physics (energy budget); (e) Dynamic meteorology (mass transfer methods); and (f) Statistics (empirical correlation with meteorological factors). Actual évapotranspiration can be estimated from: (a) Soil moisture depletion studies on small plots; (b) Tanks and lysimeter experiments; (c) Groundwater fluctuations and other mass balance techniques; (d) By means of relationships to pan evaporation; (e) Soil moisture budgets; and (f) Energy budgets. A number of évapotranspiration equations are available for application. Some of them are developed for the potential évapotranspiration determination and they can not be used directly for the estimation of a catchment or regional water balance. The determination of the exact values of the potential and actual évapotranspiration is essential for the water balance calculation. The different methods, approaches and equations give very different and, for engineering practice, unreliable results. The problem is especially complex for the flatland areas. There is general agreement that évapotranspiration is the most unreliably assessed variable in determining the catchment and/or regional water balance.

CONCLUSIONS

One may argue that the real question is: "Is hydrology in crisis?", and the definitive answer is: "No, hydrology is in the process of turbulent development". It is on the right tracks, but its route is full of surprising novelties. However hydrology and hydrologists should not neglect the basic hydrological problems. Hydrology has to come back to its roots in order to better understand the ramifications of the hydrological cycle and to more accurately calculate the water balance. At the same time hydrology should closely co-operate with other sciences in order to be better placed to find answers to future challenges. Hydrology had been and is one of the bases for the development of civilization, but in future its role should be strengthened.

There are various ways of achieving this strengthening, but no-one understands which is the most direct, correct and proper way. The concept of trial and error and assiduous interdisciplinary work on the problems of water resources management could be helpful. Water resources management has evolved into a holistic discipline where hydrological, engineering, institutional, and environmental concerns are inseparably intertwined. Hydrology needs all kinds of models and modelling, but they are only a useful tool but not a panacea. The model provides bases upon which participants may apply professional judgement and a methodology for comparing the relative effects of different management decisions. As a fundamental science hydrology can help to bridge the gap between the humanities, science, and society. This is a very difficult and responsible mission.

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