INFLUENCE OF PARAMETERS SMALL BASINS, OPERATED HYDROPOWER, ON FLOW IN THE APUSENI MOUNTAINS, ROMANIA

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Abstract

In Romania, the share of hydropower is less than half that produced in European countries, although the potential energy produced in MHC less than 10 MW is estimated at 6 TWh.

To assess hydropower potential of small watercourses in the Apuseni Mountains (Romania), have been studied the relationship between various parameters of their river basins and flow transported through the control medium during 1991-2010.

Parameters of the 9 small basins, studied (perimeter, the total length of the hydrographic network, surface, average rate, afforestation, longitudinal slope, etc.). Were determined on the 3D model of the river basin, operated by Mapsys programs and Surfer.

Between averaged flow control sections of river basins and their parameters statistically significant correlations were established. It was established that the average flow restoration in order to study hydropower potential can be used: degree of forestation, form factor and the maximum length of river sub-basins served by section considered to have statistical significance in 70% of cases studied.

Key words: hydropower potential, hydrographic basins parameters, correlations.

INTRODUCTION

Renewable forms of energy refers to energy produced by transferring energy from renewable natural processes. Thus, the energy of sunlight, the wind, flowing water, biological processes and geothermal heat can be captured by people using different methods. So unconventional energy sources, are all those sources, not using classic fuels, namely solar, wind and hydro energy (flowing water, tidal, wave, etc.).

Hydropower is one of the main components of non-conventional energy. Water energy conversion has been a major concern of all time, known as one of the oldest human concerns "to steal" water power (Baya, 1999), one which is considered by Leonardo Da Vinci "motor of the nature".

Share harnessed water power in Romania, is less than half of that achieved in European countries, where hydrological and geo-climatic conditions comparable to those of our country (Brata, Jura, 1995).

To this end, attention should be directed toward small water courses that offer real hydropower potential. Harnessing hydropower potential of rivers should be regarded with utmost interest, shifting production towards renewable energy, clean, able to provide energy independence for small communities and small businesses. Hydropower production in microhydropower (MHC) meet today's modern society, due to low cost, high safety and energy systems work, not least because almost or no impact on the environment (Leţea, Herbst, 1974).

In Romania, a country member of the European Community, energy from renewable sources in 2010 represented about 11% of total energy consumption and energy representing the energy produced by hydroelectric old 33%. In Europe, since 2005, 20/20/20 European directive known phrase suggests that by 2020 to reduce the hazards resulting from the burning of fossil fuels by 20% and produce 20% of total energy consumption from renewable energy regenerabile (http://ec.europa.eu/clima).

Considering the economic benefits of hydro energy compared to other energy sources (solar, wind, biomass) (Williamson, 2011), the question is to make maximum use of the hydropower potential of all watercourses, including small and usually in remote areas where there are small communities, sights and small entrepreneurs.

Theoretical hydropower potential is the total available energy of flowing water or precipitated on the surface of an area (the area of precipitation or discharge) or along water courses (linear), without taking into account the technical possibilities of development, loss of flow, fall and hydraulic energy conversion efficiencies in electricity (Teuşdea et al., 2012).

For an mathematical description and accurate analysis of data are useful methods presented in (Bica et al., 2006, 2010).

Evaluation of theoretical hydropower potential of a stream involves identifying favorable sites for microhydropower (MHC) knowledge flow Q, Z shares to the Black Sea and the length L of the sections (Popa, Paraschivescu, 2007).

Because the small water courses, no flow measurements, only the control sections (hydrological stations) located at the mouth of them into the river higher order to assess hydropower potential in favorable locations for MHC from inside of the basins is necessary to find correlations between flow rates measured in the control and the characteristics of basins and sub-basins components, in order to reconstruct the flow of locations (Popa, Popa, 2003).

The investigations currently known mainly known that the contribution in the formation of multi-flow measured in the control of small watershed basin Criş big plays catchment area followed by the total length of the river. Influence of watershed area on average annual flow control section being linear, distinctly significant in terms statistic (Iovan, Sabău, 2012).

This work has as main objective the establishment of the correlative links between flows measured in the control of small streams in the Apuseni Mountains (Romania) and some features of their river basins in order reconstitution of river flows in the insider sections identified as favorable sites for the construction of MHC, to assess their potential hydropower.

To determine the parameters of watershed characteristics, real help is given to the use of GIS programs specializing in watershed modeling, such as Watershed Modeling System (WMS), which was used to obtain digital terrain model (DEM), used for determined surface hydrographic network length and the average slope of the river basin sub-basins of Ergene river from Turkey (Sener, 2011).

A very important feature of the watershed that affect water flow formation is carried coverage of ground vegetation, respectively, for small watershed in mountain area afforestation. Research conducted worldwide on afforestation influence on the formation highlights the trend of reducing debt flows with increasing afforestation. However, in river basins suffer permanent changes afforestation, the different methods used to assess the impact of afforestation on flow transported flow showed large variability in the degree of forestation, requiring a period of from 8 to 25 hydrologic years to restore balance (Brown, 2013).

MATERIAL AND METHODS

The present study was performed on nine small water courses located in the Apuseni Mountains that Iada Valley, Brătcuţa Valley, Crişul Pietros Valley, Galbena Valley, Aleu Valley, Crăiasa Valley, Finiş Valley, Tărcăiţa Valley and Văratec Valley.

Watershed parameters included in the study for the nine pools are: surface basin, perimeter basin, the total length of the hydrographic network, the length and width of the basin, form factor and afforestation.

Measurements of flow from the control section of the river basin were conducted Criş Waters Directorate, Oradea, is considered a period of 20 years between 1991 and 2010.

Mathematical modeling of watershed area studied was achieved with Surfer software, digital terrain model (DEM) is then used to watershed characterization using Mapsys program, both Geographic Information Systems software category (GIS) (Figure 1).

Correlations between watershed characteristics so determined and maximum, average and minimum flow, measured in control sections were obtained using mathematical statistical methods (Brown et al., 2013), their statistical significance using t test was studied by Fisher.

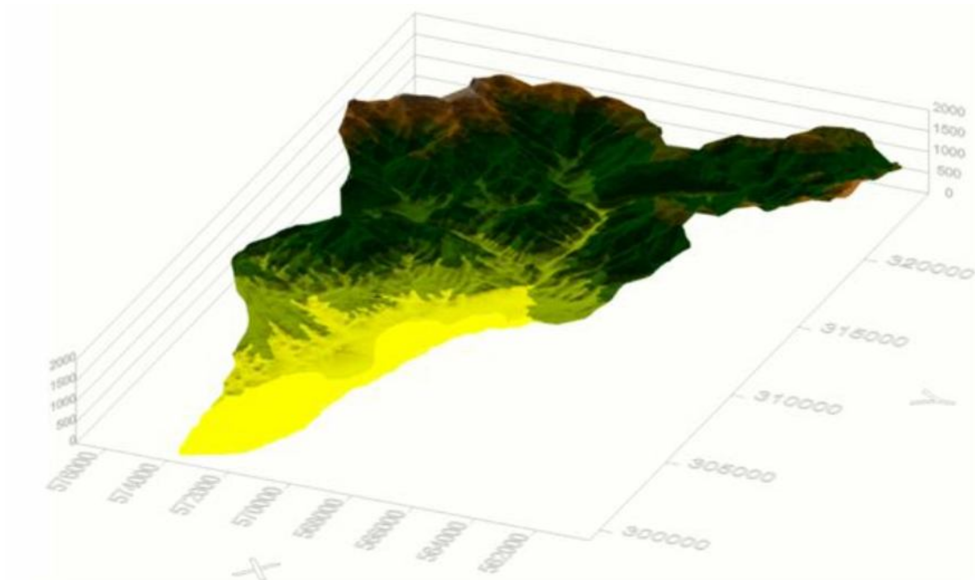

Fig. 1. The space model of the field (3D) in the hydrographical basin of the Crişul Pietros Valley

RESULTS AND DISCUSSION

To assess hydropower potential of watercourses is necessary to know the average flow being transported in sections that potential sites of future MHC. In the case of watercourses with small basins in the Apuseni Mountains, there not exist flow measurements in the interior sections, only measurements of their control sections located at the mouth into the river higher order. To reconstitute flow transported in sections of future potential sites MHC is necessary to find correlative links between flows measured in the control of the watercourse, on the one hand and catchment characteristic parameters, on the other hand, which will then be extended sub-basins, for modeling flow in sections of the site collected the MHC- tion.

Characteristics of the nine river basins studied were determined on digital terrain model (DEM) obtained using the program Surfer, which then, using the facilities of the program were measured MapSys: surface area, perimeter, total length of the network basins, maximum length, maximum width and afforestation, then calculating basin shape index.

The influence of these parameters on the flow basins maximum, average and minimum measured their control section, between 1991-2010 was tested using the statistical significance of the links between them, using t test after Ficher (Giurgiu, 1972). Correlative links so set the equations of statistical significance only in three cases for minimum flow, average flow in four cases, and five cases for maximum flow (Table 1).

Table 1

Multiannual average flows (m^3/s) in the control sections of some valleys from the forestry sector (1991-2010) (after Romanian Waters – Waters-Rivers Department)

Nr. crt.	Flow	Parameter/UM	Regression equation	R^2	Significance
1	Minimum flow	Surface (S) [km^2]	Qmin=0,0094S+0,114	0,6767	*
		Perimeter (P) [km]	Qmin =0,0006P^2-0,0491P-1,4797	0,617	-
		Total lenght (Lt) [km]	Qmin =0,008Lt+0,1427	0,538	-
		Maxim lenght (Lm) [km]	Qmin = 0,0098Lm^2-0,3051Lm+2,7079	0,6577	-
		Maxim width (lm) [km]	Qmin = 0,0244lm^2-0,1961lm +0,8137	0,4736	-
		Form factor (Ff)	Qmin =825,58Ff^2-237,87Ff+17,424	0,6717	*
		Afforestation (Af) [%]	Qmin =0,003Af^2-0,3525Af+10,261	0,7395	*
2	Medium flow	Surface (S)	Qmed=0,0076S+0,1219	0,62	-
		Perimeter (P)	Qmed =0,0007P^2-0,0545P+1,638	0,6639	*
		Total lenght (Lt)	Qmed =0,098Lt+0,1431	0,5817	-
		Maxim lenght (Lm)	Qmed = 0,0116Lm^2-0,3564Lm+3,13	0,7014	*
		Maxim width (lm)	Qmed = 0,0292lm^2-0,228lm+0,919	0,5132	-
		Form factor (Ff)	Qmed =996,09Ff^2-286,46Ff +20,922	0,723	*
		Afforestation (Af)	Qmed =0,0027Af^2-0,3101Af+8,91	0,7459	*
3	Maximum flow	Surface (S)	Qmax =0,011S+0,1066	0,7194	*
		Perimeter (P)	Qmax=0,0008P^2-0,0637P+1,8794	0,7188	*
		Total lenght (Lt)	Qmax =0,0114Lt+0,1506	0,605	-
		Maxim lenght (Lm)	Qmax =0,0134Lm^2-0,4106Lm+3,5714	0,7524	*
		Maxim width (lm)	Qmax = 0,0308lm^2-0,2242lm+0,9326	0,512	-
		Form factor (Ff)	Qmax =1115,5Ff^2-319,78Ff+23,293	0,7342	*
		Afforestation (Af)	Qmax =0,0033Af^2-0,3799Af+11,195	0,7015	*

Influence of catchment area, the formation flow is described by linear equations in all cases, indicating that the flow control section increases with increasing catchment area that collects water. These correlations were statistically significant only for the maximum flow (R^2=0,6767) and minimum flow (R^2=0,7194), calculated from measurements of 20 years. If environmental flow R2 correlation coefficient = 0.62, although the value is below the statistical significance is very close to this limit.

Perimeter watershed influences statistically significant (R^2= 0,7188) only maximum flow formation, the correlative connection type second-degree polynomial.

Our tests show that the total length of the river basin affects not statistically significant in the control flow formation.

Maximum length of watershed influence in the formation of the control flow is described by second-degree polynomial equation in which the correlation coefficient increases from minimum flow to maximum flow rates with statistical significance only for medium flow rates (R^2= 0,7014) and maximum (R^2= 0,7524).

Maximum width parameter watershed has no statistical significance for formation control flow in their sections.

The form factor of hydrographic basins as represented by the ratio of basin surface area and expressed radical deviation from the circular shape.

Ties are tested correlative polynomial of degree type, see statistically significant for all three situations (maximum, average and minimum flow) (Figure 2).

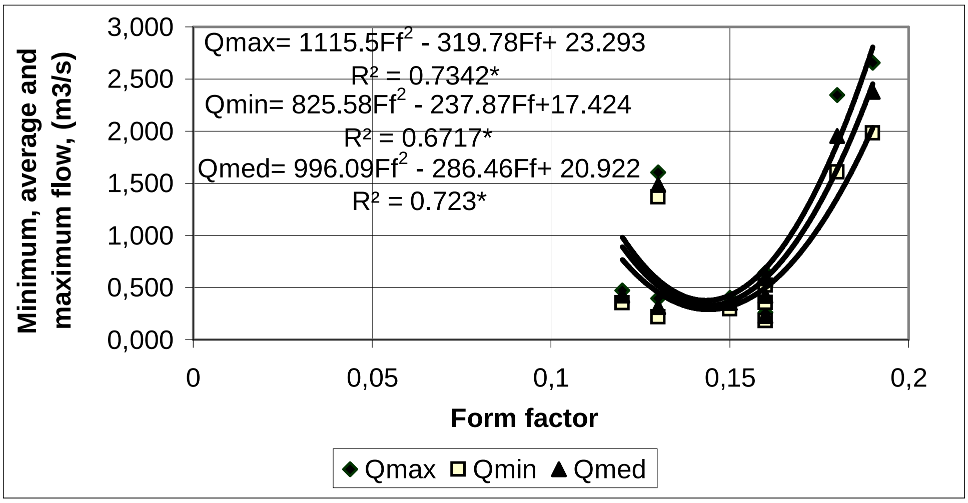

Fig. 2. Influence of form factors on the multiannual maximum, average and minimum flow from their section control

Waveforms thus obtained indicate that the lowest values of minimum flow, average and maximum values are obtained form the shape index below 0.15.

An important parameter of the studied catchments with forest coverage basin surface (afforestation), expressed as a percentage of total area.

Correlations made between the three types of flow and degree of forestation, second-degree polynomial type are statistically significant (Figure 3).

Studies worldwide and in our country showed that forested areas in river basins flow reduces transported, because the soil retain and store much of the basin surface rainfall. This situation occurs in cases basins studied, indicating reduced form regression curves transported flows with increasing rate of afforestation, but only up to about 60% from the total surface.

Flow reforestation increase the percentage of the watershed is higher than 60% can be explained by the fact that in the study area in recent decades have been exploited to shave large areas of forest, and to restore the hydrological balance of the area are required decades.

Analyze the statistical significance of the links correlative study shows that restoring flows in sections of MHC potential sites - most countries of sub-basins indicate parameters that serve these sections are: the afforestation that allow the reconstitution medium flow in 74,59% of cases, factor form, which includes perimeter and sub-surface, covering the statistical average flow of 72,3%, and that the maximum length of the covering sub 70,14% of cases.

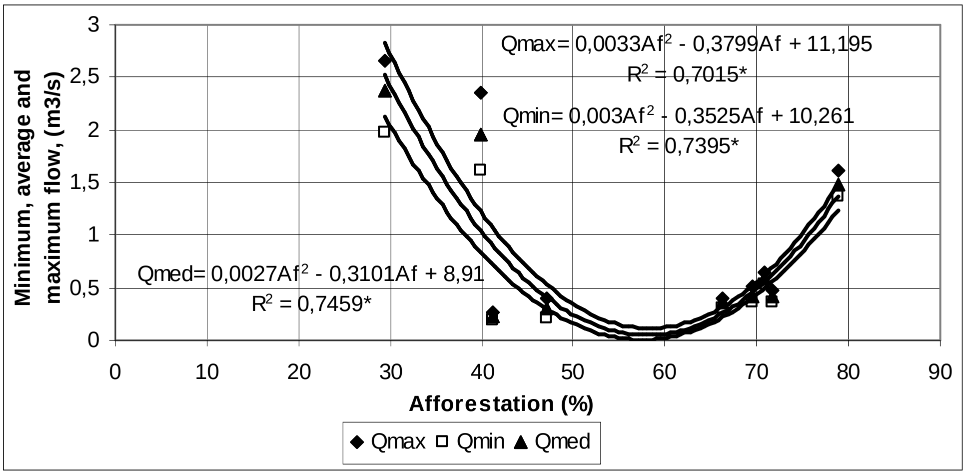

Fig. 3. Influence of afforeatation hydrographic basins on the multiannual maximum, average and minimum flow from their section control

CONCLUSIONS

Watershed characteristics studied were determined on digital terrain model (DEM) obtained using the program Surfer, the model measurements performed with MapSys program, both Geographic Information Systems software category (GIS).

Correlative established links between the characteristics of the nine river basins (surface, perimeter, length of the hydrographic networks, maximum length of the basin, maximum width of the basin, form factor and afforestation) on the one hand and minimum flow, average and maximum of sections control, on the other hand, the statistical significance in three cases for minimum flow, average flow in four cases, and five cases for maximum flow.

Analyze the statistical significance of the links correlative studies show that the average flow sections reconstitution potential sites of MHC-tion is possible when using the afforestation, form factor and that the maximum length of sub-basins from which water is collected throughput by section considered. Such flows can be reconstructed average flow over 70% of cases.

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