ASSESSMENT OPPORTUNITIES OF SMALL WATERCOURSES FLOWS, FROM MOUNTAIN BASIN AREA CRIŞ, NECESSARY FOR DESIGNING MICROHYDROPOWER

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Abstract

In Romania is stimulated production of hydroelectric power in microhidocentrale, (MHC) hydroelectric plants with an installed capacity below 10 MW, with facilities for accessing EU funds and awarding 3 green certificates for each MWh produced and delivered national energy system or consumers.

The purpose of site selection on MHC-sized streams in small forest catchments, and to determine the type of turbine is used multiannual average flow rate of water transported through that section respectively.

Because the streams of small basins of the upper basin Cris, there are no systematic measurements than in the control flow from the mouth of that river, to obtain the location of the sections flow MHC literature their restoration specialist recommended by analogy with flows from adjacent basins.

To reconstitute these different flow rates were analyzed correlations between flow maximum, average and minimum determined in the control, for a period of 20 years, 9 small basins and some characteristics of these basins.

Of regression equations by a factor of two independent factors and three independent factors best results in simulating the three categories of flow are obtained using linear correlations with two independent factors, area and perimeter or surface watershed and river network length, which are distinct statistically significant.

Key words: microhydropower (MHC), hydropower potential, flow sizing, watershed characteristics, multiple correlations.

INTRODUCTION

Global challenges due to the economic crisis and global energy, overlapped need to protect the environment have led to the increase of the total energy consumption of conventional energy.

Thus, to reduce emissions of greenhouse gases, to comply with the Kyoto Protocol, United Nations Framework Convention on Climate Change, the European Community aims since 2005 by Directive 20/20/20 phrase known as to 2020, to reduce the hazards resulting from the burning of fossil fuels by 20% and increase the share of non-conventional energy, renewable products by 20%. For the conditions of our country, which in 2005 produced 17.8% of total renewable energy, this percentage was set at 24% (EC Directive 28, 2009).

Non-conventional energy sources, generally called renewable sources are the natural environment, which unlike conventional energy sources (fossil fuels, nuclear) are regenerated by natural processes, represented by: solar, wind, water or energy hydro, geothermal and biomass energy.

Hydropower water, one of the most common energy sources exploited since ancient times, with water wheels, is considered one of the cheapest forms of electricity production and one of the cleanest sources of energy (Baya, 1999).

In Romania, a country member of the European Community, renewable energy produced in 2010 accounted for 11% of consumption, and hydropower represent a third of total energy consumption in most of the energy produced by large hydroelectric plants. Comparing this situation with the European Community countries share hydropower is less than half the energy produced in EU countries hydrological and geo-climatic conditions comparable to those of us (Jura et al., 1995).

Since the construction of hydropower plants are very expensive because favourable locations on major rivers have been largely exhausted, the remaining possibility of designing small rivers in the upper watershed areas less accessible mountain that lends itself to the production SHP electricity (MHC), which have a lower installed power of 10 MW.

Since the river has a hydropower potential of Romania linear 300 kW / km, linear theoretical potential is estimated at 70 TWh / year, of which harnessed the potential was estimated at 3.6 TWh / year, which was updated to potential 40 TWh / year, of which microhidroelectric potential is 3.5 TWh / year (Popa et al., 2006).

To stimulate the production of electricity is promoted by building facilities MHC accessing EU funds and green certificates to producers, 3 for each MWh produced and delivered to the national power grid or consumers (Act 220/2008).

The current global trend is to extend the arrangement of small streams into the small streams that end, in addition to large hydropower plants with installed capacity greater than 10 MW and small hydro, rated between 100 kW and 10 MW are introduced the concepts of micro and mini hydropower (5KW - 100 KW) and even producing pico hydro below 5 KW (Williamson S.J. et al., 2011).

Choosing the best locations, in terms of technical and economic aspects of MHC-tion studies shall follow the hydropower potential of rivers that make up the National Hydropower cadastre. Theoretical hydropower potential could be: surface, when taken into account rainfall and linear catchment surface, when it is considered multiannual average flow carried by a section of a stream (Stematiu, 2008).

For determining the type of turbine is equipped MHC, in addition to water loss represented by the difference in level between the water level in the collecting tank and the elevation of the turbine, it is necessary to know the monthly average flow rate determined over a period of for decades (Driscoll, 2008).

Therefore, the most important feature of a small stream needed to design the flow of MHC's is possible to locate these sections. Because only systematic measurements of flows in small catchments are in the control of the spill are not known flow rates of the possible sites of MHC-river sites on their network.

The most favorable sites of MHC - sites on the river are the small river estuary sections of tributaries, which bring additional water intake (Iovan, 2012).

Thus, for the preparation of a hydroelectric cadastre small stream in the mountains, they choose possible locations of MHC sites downstream tributaries spilling and calculate theoretical hydropower potential of the sector line between two sections (Teuşdea et al., 2012).

For an mathematical description and accurate analysis of data are useful methods presented in (Bica et al., 2006, 2012).

After Popa , Popa (2003), for the river k relationship is used:

$$p_k = 9{,}80665\frac{\overline{Q_k}\cdot\Delta Z_k}{\Delta L_k};\ [KW/km]$$

where:

p_k – theoretical linear specific potential of the sector *k*;

Q_k – average flow of sector *k*, determined as the average between the sections delineating the [m^3/s];

ΔZ_k – elevation difference between the ends of the sector *k* [m];

ΔL_k – the length of the sector *k* [Km].

Since the flow of the above-mentioned sections are not known for the evaluation of the flow of their restoration is proposed according to the known flow control section in which the measurements were made by analogy with the neighboring basins. This method leads to erroneous results due to differences in watershed characteristics that determine the formation of leaks in the mountains.

In the absence of flow measurements of small rivers, the location of sections MHC - s, the flow rate Q can be computed with relationship (Zăvoianu, 2006):

$$Q = s\left(\frac{S\cdot h}{t}\right);\ [m^3/s]$$

where:

s – specific catchment runoff coefficient that;

S – catchment area upstream of the section [Km^2];

h – average height of rainfall [mm];

t – during the calculation of average rainfall [s].

The relationship above can be used when there is basin lengthy and systematic records of precipitation in mountainous areas showing these variations. Knowing the rate of precipitation and control section, recorded in the same period and the area of the basin can be determined by the specific flow coefficient, by which it can then determine the flow of sites in proportion to the surface of the pool upstream of the section which collects the surface of the water.

Man et al. (2010) mentions the possibility of determining the maximum flow of a specific river basin used cross-sectional design ofdrainage channels, the relation:

$$q_{max} = \frac{C}{\sqrt[x]{S}}; \quad [l/s\ şi\ ha]$$

where: C and x are constants which take into account specific surface roughness and size of drainage basin.

This relationship can be used to reconstitute the maximum flow collected over a surface of the basin, where it causes the two unknowns, C and x which are stable for a given tank. The two unknowns would determine whether the next section of the review is systematic measurements of flow into a second section of the surface of the pool.

For small basins of the Apuseni Mountains forest were established correlations between average annual flow of their control sections and some characteristics of the area, perimeter and length of the hydrographic network connections and linear correlation degree polynomial being significant statistically (Iovan et al., 2012).

This paper aims to average annual flow from measured in the control of some river basins in the mountain basin Criş establish possibilities of extrapolating their possible location MHC's through their multiple correlations with some features of their river basins.

MATERIAL AND METHOD

The 9 small basins in the mountain basin Criş, covered by this study are: Iada Valley, Brătcuţa Valley, Crişul Pietros, Galbena Valley, Aleu Valley, Crăiasa Valley, Finiş Valley, Tărcăiţa Valley and Văratec Valley.

To analyze the influence on the flow characteristics of these basins measured in the control of water courses have been taken into account the following characteristics: catchment area S [km^2], river network length Lr [km], perimeter P [km], the maximum length Lm [km], maximum width lm [km], shape index Ff, the average H [m], the main course length Lc [km], average longitudinal slope of the main course I [%] and the percentage of afforestation A [%].

To determine these characteristics is shown using computer programs in the category of Geographic Information Systems (GIS) spatial modeling watershed specialist (Sener, 2011).

We have used for the determination of watershed-scale topographic maps 1:20.000, which was built using digital terrain model (DEM) for each river basin (Figure 1), using Surfer TopoSys and MapSys programs (Marton, 2007).

River basin shape index was calculated using the values of the area S and perimeter P of watershed caused the digital terrain model, the relation:

$$\varphi = 0{,}282\frac{P}{\sqrt{S}};$$

To obtain the maximum flow Q_{max}, Q_{min} average and minimum Q_{med} were used average monthly records for a period of 20 years (from 1991 to 2010), conducted by the Water Department Criş Oradea.

RESULTS AND DISCUSSION

In order to identify possible correlative links between watershed characteristics studied and measured in the control flow has been established correlation matrix, which were taken into account 10 parameters and characteristics of the annual flow, maximum, average and minimum (Table 1).

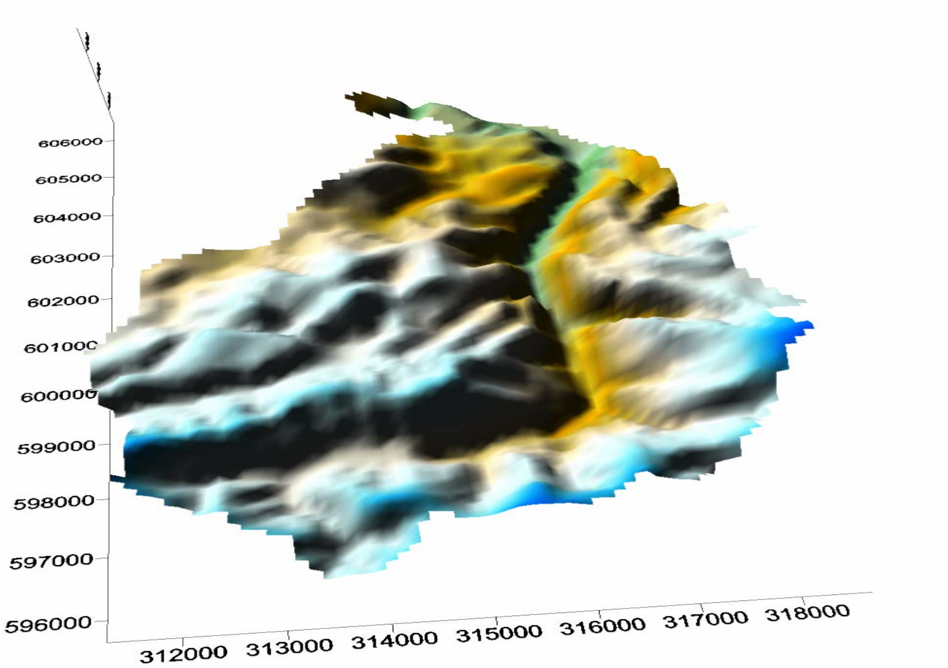

Fig. 1. The digital terrain model (DEM) of hydrographical basin's Brătcuţa Valley

Table 1

The correlation matrix of flows with characteristics of hydrographic basins

No. Crt.	The characteristic of hydrographic basins	Maximum Flow Qmax [m^3/s]	Medium Flow Qmed [m^3/s]	Minimum Flow Qmin [m^3/s]
1	Surface (S) [km^2]	0.7194	0.6767	0.6200
2	Length of river network (Lr) [km]	0.6050	0.5817	0.5380
3	Perimeter (P) [km]	0.5885	0.5417	0.4883
4	Maxim width (lm) [km]	0.4170	0.4160	0.3792
5	Maxim length (Lm) [km]	0.4025	0.3654	0.3236
6	Form factor (Ff)	0.3719	0.3504	0.3166
7	Average height (H) [m]	0.2898	0.2776	0.2852
8	Length of river (Lc) [Km]	0.3122	0.2689	0.2284
9	Average declivity (I) [%]	0.2648	0.2316	0.2222
10	Afforestation (Af) [%]	0.2248	0.2030	0.1593

Analysing the correlation relations established between watershed characteristics analyzed three categories of flow is noted that only the first three characteristics, formation flow can be attributed to them in 50% of cases.

Linear correlations with three independent factors made between area and perimeter length of watershed and river system that explains the formation of the control flow in 70% of cases (Table 2).

Table 2

Linear correlations with three independent factors

No. crt.	Established relationship $Q = a_0 + a_1X1 + a_2X2 + a_3X3$;	Correlation report R^2	Signifi-cance
1.	Qmax = - 0,009338 + 0,0018985*S + 0,009667*Lr + 0,0027768*P	0,792422	*
	Qmax = 0,977041 + 0,021396*Lr – 0,03554*P + 0,002251*S	0,746725	*
	Qmax=-0,12157 + 0,018734*P + 0,003649*S – 0,00122*Lr	0,794437	*
2.	Qmed = 0,019531 + 0,001709*S + 0,008241*Lr + 0,002143*P	0,773903	*
	Qmed=0.704989 + 0,018905*Lr – 0,02886*P + 0.001299*S	0.722764	*
	Qmed= -0,11514 + 0.016223*P + 0,003375*S – 0,0005*Lr	0.770662	*
3.	Qmin = -0,046829 + 0.001429*S + 0,006681*Lr + 0,001661*P	0,731182	*
	Qmin=0.189451 + 0.00651*Lr + 0.002448*P - 0.00055*S	0.718187	*
	Qmin=-0.05902 + 0.013165*P + 0.002716*S - 0.00043*Lr	0.73342	*

The highest correlation ratios obtained in the simulation of maximum annual flows in all analyzed characteristics (0.746725 to 0.794437). Of the three possible combinations most appropriate is the maximum and minimum flow rates: Perimeter, Area and Length hydrographic network, while average annual flow for the combination: Area, Length and perimeter river system.

Although in all cases these correlations are statistically significant, correlation ratios are higher than for simple linear correlations established previously with the same characteristics of the watershed.

To analyze the influence of two factors of the three analyzed using linear correlations with two independent factors, reports significant correlation indicates that distinct links statistically significant (Table 3).

Table 3

Linear correlations with two independent factors

Flow Q [m^3/s]	Established relationship $Q = a_0 + a_1X1 + a_2X_2$;	Correlation report R^2	Significance
Maximum flow Q_{max}	Qmax = 0.138667 + 0.015216*S – 0.00506*Lr	0.854532	**
	Qmax = 1.280408 + 0.030697*S – 0.05963*P	0.904788	**
	Qmax = -0.06743 + 0.007322*Lr + 0.011176*P	0.783248	*
Medium flow Q_{med}	Qmed = 0.13374 + 0.011986*S – 0.00312*Lr	0.825815	**
	Qmed = 1.246035 + 0.028395*S – 0.05752*P	0.892011	**
	Qmed = -0.061906 + 0.008315*Lr + 0.004163*P	0.763705	*
Minimum flow Q_{min}	Qmin = 0.138667 + 0.015216*S – 0.00506*Lr	0.789592	*
	Qmin = 1.120998 + 0.024406*S – 0.05076*P	0.865253	**
	Qmin = 0.126778 + 0.007727*Lr + 0.000816*P	0.733555	*

Of the three possible combinations stands the simulation results of the three categories of flow area S and perimeter P use watershed analysis. Close results are obtained for determining the maximum and average flow rates and with area S and length river system Lr.

Whereas our study aimed to establish the means for restoring flow maximum, average and minimum points of the possible location of some MHC's, within river basins are recommended linear equations with two independent factors, distinct statistically significant, which provides a higher confidence level linear equations with one factor or three independent factors.

To assess the onset of annual average, in a section on the main water fin can use chart Figure 2, the input data are the characteristics of water collection basin section considered, namely its area and perimeter.

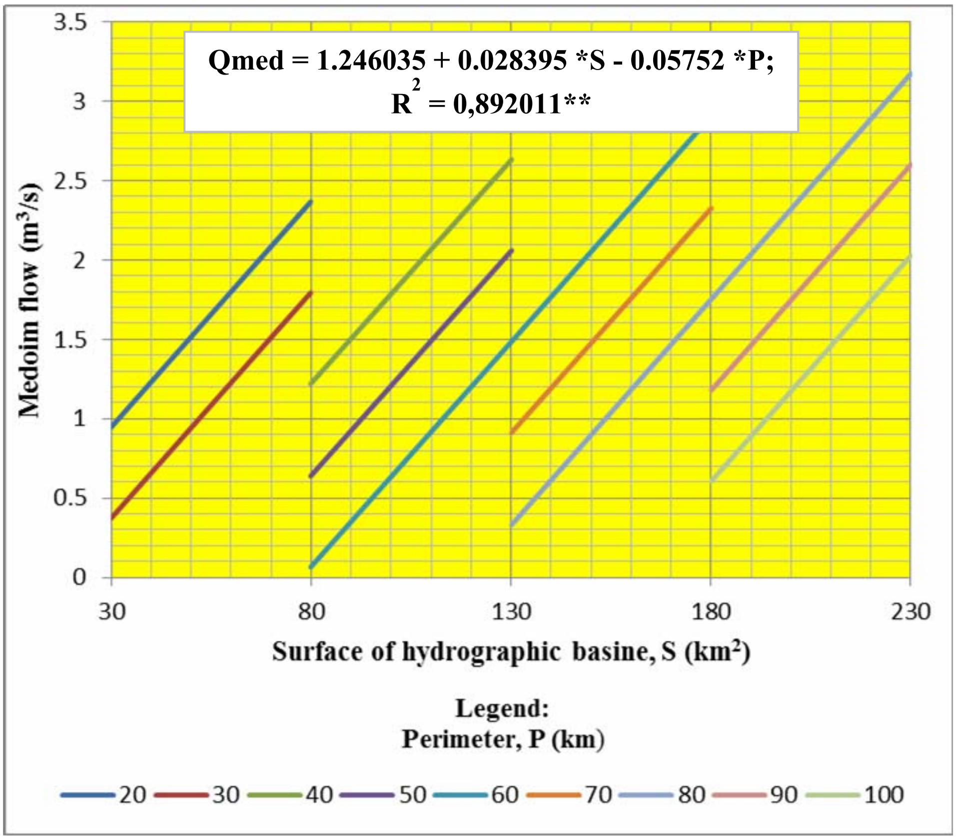

Fig. 2. The link between medium flow Q_{med} (m^3/s) and surface S (Km) and respectively Perimeter P (Km) of the hydrographic basens

These characteristics can be determined using a topographic map of the basin respectively or by spatial pattern of land (DEM) using any program category Geographic Information Systems (GIS).

CONCLUSIONS

Given the lack of systematic measurements of flow in watercourses to be furnished with SHP (MHC) main problem that arises in determining their location and choice of turbine is restoring flow in that section of the river.

Literature recommended to reconstitute the flow field by analogy with neighboring catchment basin or on the surface times the area and rainfall recorded in a given period of time.

Due to the small catchment basin at the top of Criş are systematic measurements of flow in the control of their debts to study the possibility of reconstitution of the possible sites of MHC - sites using multiple linear regression equations, with three two factors, represented by some features of these basins. Established regression equations are significant and distinct statistically significant.

To reconstitute annual average flow of potential sites of MHC sections is recommended linear regression equation two factors Qmed = 1.246035 + 0.028395 x S - 0.05752 x P, the ratio of correlation R2 = 0.892011 distinct statistically significant, the two factors perimeter surface S and P may be derived digital terrain model (DEM) using geographic Information Systems software category (GIS).

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