ISSN 1821-1046
UDK 630

INSTITUTE OF FORESTRY
BELGRADE

INSTITUT ZA ŠUMARSTVO
BEOGRAD

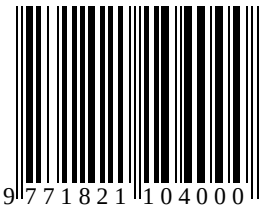
SUSTAINABLE FORESTRY ODRŽIVO ŠUMARSTVO

COLLECTION
TOM 67-68

ZBORNIK RADOVA
TOM 67-68

BELGRADE BEOGRAD
2013.

ISSN 1821-1046



ISSN 1821-1046
UDK 630

INSTITUTE OF FORESTRY
BELGRADE

INSTITUT ZA ŠUMARSTVO
BEOGRAD

SUSTAINABLE FORESTRY ODRŽIVO ŠUMARSTVO

COLLECTION
TOM 67-68

ZBORNIK RADOVA
TOM 67-68

BELGRADE BEOGRAD
2013.

INSTITUTE OF FORESTRY BELGRADE

PROCEEDINGS

INSTITUT ZA ŠUMARSTVO BEOGRAD

ZBORNIK RADOVA

Publisher
Institute of Forestry
Belgrade, Serbia

Izdavač
Institut za šumarstvo
Beograd, Srbija

For Publisher
Ljubinko Rakonjac, Ph.D.

Za izdavača
Dr Ljubinko Rakonjac

Printed in
100 copies

Tiraž
100 primeraka

Printed by
Black and White
Beograd

Štampa
Black and White
Beograd

Belgrade, 2013

Beograd, 2013

Cover Page: Author of the Photos Tatjana Ćirković-Mitrović, M.Sc.
Naslovna strana: Autor fotografije mr Tatjana Ćirković-Mitrović

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

630

SUSTAINABLE Forestry : collection = Održivo šumarstvo = zbornik radova / chief
editor = glavni i odgovorni urednik Snežana
Rajković. - 2008, T. 57/58- . - Belgrade (Kneza Višeslava 3) : Institute of forestry, 2008- (Beograd : Black and White). - 24 cm

Godišnje. - Je nastavak: Zbornik radova - Institut za šumarstvo = ISSN 0354-1894
ISSN 1821-1046 = Sustainable Forestry
COBISS.SR-ID 157148172

CONTENT SADRŽAJ
TOM 67-68

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 67-68, 2013 ZBORNIK RADOVA 67-68, 2013

UDK 630*384.3:627.132(282 Trgoviški Timok)=111
Original scientific paper

ANALYSIS OF SILTATION SLOPE DEPENDENCE ON GRAIN SIZE COMPOSITION OF SEDIMENT IN TORRENT STREAMS OF TRGOVISKI TIMOK DRAINAGE BASIN

Svetlana BILIBAJKIĆ[1], Tomislav STEFANOVIĆ[1], Radovan NEVENIĆ[1], Goran ČEŠLJAR[1], Renata GAGIĆ SERDAR[1], Zoran PODUŠKA[1], Ilija ĐORĐEVIĆ[1]

Abstract: *The siltation slope is the slope of the upper surface of the deposited material in the storage area upstream of the constructed dam. Silting up is a complex process and the assessment, i.e. the forecast of the slope of siltation is a major issue in the practice of torrent management. This paper analyses the dependence of newly formed siltation slopes on grain size composition of sediment, from the siltations of the constructed dams in torrent streams of the Trgoviski Timok catchment basin. The analysis of the dependence of newly formed siltation slope on grain size composition of sediment was performed by the method of modeling as the basic method. Regression and correlation analyses were applied as the specific research methods. The obtained results show the high correlation between the siltation slope and grain size composition of sediment, based on which it can be concluded that the obtained model is a good base for the slope of siltation forecast in future.*

Key words: Trgoviski Timok, dam, siltation slope, grain size composition of sediment

ANALIZA ZAVISNOSTI PADA ZAPLAVA OD GRANULOMETRIJSKOG SASTAVA NANOSA U BUJIČNIM VODOTOCIMA SLIVA TRGOVIŠKOG TIMOKA

Abstract: *Pad zaplava je pad gornje površine nataloženog materijala u akumulacionom prostoru uzvodno od izgrađene pregrade. Formiranje zaplava je složen*

[1] Institute of Forestry, Kneza Viseslava 3, Belgrade, Serbia

proces, a određivanje veličine pada zaplava predstavlja značajan problem u praksi uređenja bujičnih vodotoka. U ovom radu analizirana je zavisnost novoformiranih padova zaplava od granulometrijskog sastava nanosa, na zaplavima izgrađenih pregrada u bujičnim vodotocima sliva Trgoviškog Timoka. Analiza zavisnosti novoformiranog pada zaplava od granulometrijskog sastava nanosa urađena je metodom modeliranja, kao osnovnom metodom, a korišćena je regresiona i korelaciona analiza kao konkretna istraživačka metoda. Dobijeni rezultati pokazuju značajnu povezanost između pada zaplava i granulometrijskog sastava nanosa, na osnovu čega se može zaključiti da dobijeni model predstavlja dobru osnovu za prognozu pada zaplava.

Ključne reči: Trgoviški Timok, pregrada, pad zaplava, granulometrijski sastav nanosa

1. INTRODUCTION

The determination of the length of the slope of siltation is a major issue in the practice of torrent stream management. The need to find the practical solution to this problem resulted in numerous formulas for the assessment of the slope of siltation of which usually are used formulas by Thiery, Pimpirev, Valentini, Jaggy, Valtyni, Chezy, Šamov, Strikler, Krey, Lane, Mirzazage-a, Schields, Egiazarov, Mayer-Peter, formulas of regional analytical dependencies by Biolčev, Kostadinov and Velojić (Kostadinov, 1996, Todosijević, 2004, Velojić, 2002, Kostadinov, 1989). By analyzing these formulas can be concluded that the formation of the siltation slope the decisive roles have stream bed slope and grain-size composition of the sediment (Bilibajkić, 2011).

This paper analyses the dependence of newly formed siltation slopes on grain size composition of sediment from the siltations of the constructed dams in torrent streams of the Trgoviski Timok catchment basin.

2. MATERIAL AND METHOD

This paper presents the researches conducted in the Trgoviški Timok drainage basin in the following torrent streams: Melo, Vidovacka River, Oreovica, Lesjanski Do and Trgoviska River.

Trgoviški Timok is the first rigth tributary of the Beli Timok River, which meets Svrljiski Timok in Knjazevac, at the altitude of 210 meters above the sea level. The spring of Trgoviški Timok is in Stara Planina mountain, in the vicinity of Midzor Summit (located at 1,630 meters above the sea level), and is composed of Crnovrska river and its component stems. Crnovrska reka meets Strmna River near Balta Berilovac settlement and forms Trgoviski Timok. The total length of Trgoviški Timok is 54.1 km and the drainage basin area is 536.9 km^2. The drainage basin is oblong-shaped, the right side of it is wide and steep, and the leftside is very narrow and steep.

The hydrographic network of this river is well-developed and it consists of a number of small and great tributaries. The most important right tributaries are: Janjska, Inovska, Grabovnicka, Papratska, Zukovacka and Trgoviska River and the most important left tributaries are: Strmna Reka, Crvencica, Izvorska Reka, Melo

and Lesjanski Do. These streams, along with their tributaries, consitute well-developed hydrographic network made of 216 torrent streams.

Trgoviska River is the first large, right tributary of Trgoviški Timok, looking upstream from the confluence with Svrljiski Timok. The hydrographic network of this river is well-developed. The main stream consists of two component rivers: right one called Lokvanjska River and the left one called Vidovacka River. The total drainage basin area of Trgoviška River is 22.77 km^2. Its length is 9.5 km and the mean slope is 6.3%. The drainage basin terrain features are mostly hilly. The average slope gradient in the drainage basin ranges from 35 to 40%. The confluence of Trgoviska River in Trgoviski Timok is near the settlement Trgovište.

Vidovačka River consists of two arms: the right one - Garnovica, and the left one - Crna River. The drainage basin is hilly with steep slope gradients ranging from 30 to 40 %, and its area is 8.41 km^2. The length is 5 km and the mean streambed slope is 8.1 %.

Oreovica is the right tributary of Aldinacka River and is located in Gornja Sokolovica settlement. The drainage basin area of this tributary is 0.82 km^2, the main watercourse is 1.4 km long, and the mean streambed slope is 14 %. The drainage basin is hilly, with the steep sides of mean slope of 30 %.

Lesjanski Do is the left tributary of Trgoviški Timok. Its spring is in the place called Goleme Livade. The catchment is hilly with the mean gradient of 30 %. The drainage basin area is 11.67 km^2, the watercourse is 6.65 km long, and the mean streambed slope is 5.5 %.

Melo is the third left tributary of Trgoviski Timok, looking upstream from the confluence. The drainage basin is 5.25 km^2. The main watercourse is 4.8 km long and the mean streambed slope is 7.5 %. The catchment is hilly, with the mean gradient 40 %.

Data on the current grade level of siltation were obtained by geodetic surveying of longitudinal profiles of formed siltation behind dams. Surveying was performed by leveling. Based on the data obtained by geodetic surveying in the field the longitudinal profiles of siltation are drawn and based on them were determined values of siltation slopes.

For the needs of the grain size analysis of bedload behind of every dam the sample of sediment has been taken. The sample has been taken from the area of 1.0 m^2 (1.0×1.0) to a depth of the largest grain according to the methodology of Leo Skatula (Kostadinov, 1979) and passed through sieves of diameter of 100 mm to 0.1 mm. Larger pieces of sediment were measured on the spot.

Analysis of dependence of newly formed siltation slope on grain size composition of sediment was performed by method of modelling, as the basic method, and regression and correlation analyses were used as the specific research methods.

3. RESULTS

Researches included twenty constructed longitudinal objects (dams) with formed siltation in Trgoviski Timok drainage basin.

In order to consider dependence of siltation slope and sediment characteristics, the granulometric analysis of sediment formed from siltation was performed. By passing through a series of sieves and measuring of bedload samples taken from siltation of dams, the granulometric curves were obtained from which were taken the following values of characteristic diameter of sediment.

d_{30} – grain size of sediment at 30% share of weight parts on the total weight of sediment,
d_{50} – grain size of sediment at 50% share of weight parts on the total weight of sediment,
d_{60} – grain size of sediment at 60% share of weight parts on the total weight of sediment,
d_{75} – grain size of sediment at 75% share of weight parts on the total weight of sediment.

In Table 1 are shown values of siltation slope and characteristic diameters of sediment.

Table1 . *Siltation slope and diameters of sediment*

No.	Origin	I_z (%)	d_{30} (mm)	d_{50} (mm)	d_{60} (mm)	d_{75} (mm)
I	**Trgoviska River**					
1	Dam No. 1	1,82	7,5	25,0	38,0	68,0
II	**Vidojevacka River**					
1	Dam No. 1	0,89	3,9	11,0	17,9	32,0
2	Dam No. 2	2,96	6,0	16,5	22,0	36,0
3	Dam No. 3	2,06	5,8	17,0	22,0	36,0
4	Dam No. 5	2,55	20,0	55,0	59,0	108,0
5	Dam No. 6	2,48	4,8	28,0	38,0	51,0
6	Dam No. 7	2,69	9,0	22,0	32,0	70,0
III	**Oreovica**					
1	Dam No. 1	2,92	19,3	60,0	92,0	136,0
2	Dam No. 2	4,09	44,0	76,0	86,0	114,0
3	Dam No. 3	3,33	7,8	21,0	32,0	46,0
IV	**Bujica Melo**					
1	Dam No. 1	6,22	21,2	52,5	117,0	171,0
2	Dam No. 2	4,83	25,0	50,0	62,0	88,0
3	Dam No. 3	5,21	32,0	61,0	95,0	132,0
4	Dam No. 4	4,99	8,5	38,0	49,0	82,0
5	Dam No. 5	6,56	28,0	70,0	80,0	97,0
6	Dam No. 6	10,70	5,8	12,0	17,1	32,0
7	Dam No. 7	5,22	25,0	55,0	72,0	101,0
8	Dam No.8	11,47	24,0	75,0	95,0	132,0
9	Dam No. 9	6,59	42,0	78,0	101,0	140,0
V	**Lesjanski do**					
1	Dam No. 1	1,04	1,15	1,2	1,3	5,2

Using the obtained data the scatter diagrams were made based on which several alternative functional forms (linear, degrees, exponential and logarithm) were defined. Of that forms was selected the one that was the best adapted to the given measured data and had the highest percentage of explained variations.

Picture 1. *Trgoviska River siltation of dam No. 1*

Picture 2. *Torrent Melo siltation of dam No. 1*

Siltation slope dependences on grain size composition of sediment at 30% share of weight parts on the total weight of sediment is presented in the exponential form that by suitable transformation is translated into a linear form due to application of the necessary statistical methods and tests. This regression is characterized by 43% explained variations (R^2 = 0.43) (Figure 1, Table 2). The correlation coefficient is significantly different from 0. The standard errors of the assessment of parameters and the respective t-statistics show that the parameter defining sediment at the apppropriate significance level (0.05) is sufficiently accurate while the free parameter is insignificant.

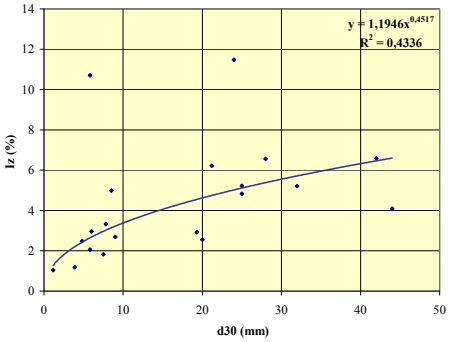


Figure 1. *Siltation slope dependence on grain size composition of sediment at 30% share of weight parts on the total weight of sediment in studied torrent steams of Trgoviski Timok drainage basin (simple correlation)*

Table 2. *Regression parameters $I_z=f(d_{30})$*

$I_z = f(d_{30})$			
$y = a\,x^b$			
a=1,194	$S_{(a)}$=0,3227	$t_{(a)}$=0,5511	$p_{(a)}$=0,5883
b=0,451	$S_{(b)}$=0,1217	$t_{(b)}$=3,7121	$p_{(b)}$=0,0016
R=0,6585	R^2=0,4336		R^2_{cor}=0,4021
F(1,18)=13,780	p<0,00159		S_c=0,5025
$I_z = 1{,}194 \times d_{30}^{0.451}$			

Analysis of the slope of siltation dependence on grain size composition of

sediment at 50% share of weight parts on the total weight of sediment gives regression model in exponential form. By this regression is explained 39% of variations (R^2 = 0.3973). The correlation coefficient 0.63 points out at significant correlation between analyzed parameters (Table 3). The standard errors of the assessment of parameters and the respective t-statistics show that the parameter defining sediment at the apppropriate significance level (0.05) is sufficiently accurate while the free parameter is insignificant.

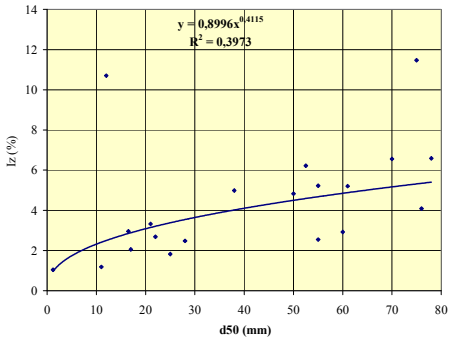


Figure 2. *Siltation slope dependence on grain size composition of sediment at 50% share of weight parts on the total weight of sediment in studied torrent steams of Trgoviski Timok drainage basin (simple correlation)*

Table 3. *Regression parameters $I_z=f(d_{50})$*

$I_z = f(d_{50})$			
$y = a\ x^b$			
a=0,899	$S_{(a)}$=0,4245	$t_{(a)}$=-0,2492	$p_{(a)}$=0,8060
b=0,411	$S_{(b)}$=0,1195	$t_{(b)}$=3,4444	$p_{(b)}$=0,0029
R=0,6303	R^2=0,3973		R^2_{cor}=0,3638
F(1,18)=11,864	p<0,00289		S_c=0,5184
$I_z = 0{,}899\ x\ d_{50}^{\ 0.411}$			

Analysis of the slope of siltation dependence on grain size composition of sediment at 60% share of weight parts on the total weight of sediment is presented by exponential form that fits the best to the given data. By this form are explained 39% of variations. The correlation coefficient R = 0.62 points out at significant correlation between slope of siltation and grain size composition of sediment at 60% share of weight parts on the total weight of sediment. The standard errors of the assessment of parameters and the respective t-statistics show that the parameter defining sediment at the apppropriate significance level (0.05) is sufficiently accurate while the free parameter is insignificant that indicates the possible deviations of its value.

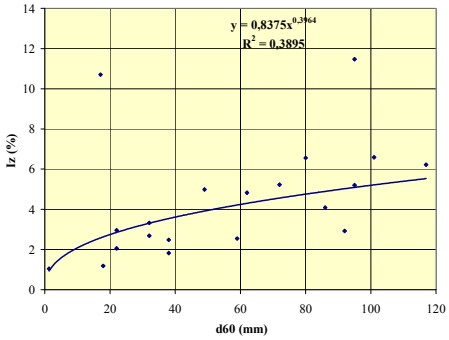


Figure 3. *Siltation slope dependence on grain size composition of sediment at 60% share of weight parts on the total weight of sediment in studied torrent steams of Trgoviski Timok drainage basin (simple correlation)*

Table 4. *Regression parameters $I_z=f(d_{60})$*

$I_z = f(d_{60})$			
$y = a\,x^b$			
a=0,837	$S_{(a)}$=0,4546	$t_{(a)}$=-0,3928	$p_{(a)}$=0,6991
b=0,396	$S_{(b)}$=0,1170	$t_{(b)}$=3,3887	$p_{(b)}$=0,0033
R=0,6241	R^2=0,3895		R^2_{cor}=0,3556
F(1,18)=11,483	p<0,0033		S_c=0,5217
$I_z = 0{,}837 \times d_{60}^{0.396}$			

Analysis of the slope of siltation dependence on grain size composition of sediment at 75% share of weight parts on the total weight of sediment gives regression model in exponential form. This regression is characterized by 37% of explained variations, the correlation coefficient that is significantly different from 0 (R = 0.61) and statistically significant assessment of parameter defining sediment at the apppropriate significance level (0.05).

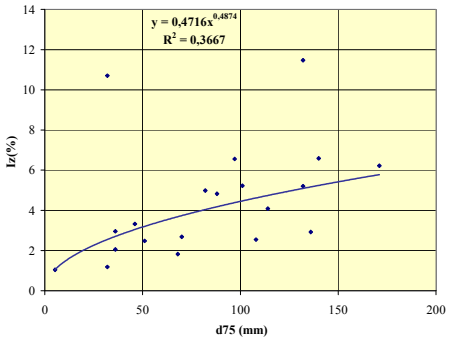


Figure 4. *Siltation slope dependence on grain size composition of sediment at 75% share of weight parts on the total weight of sediment in studied torrent steams of Trgoviski Timok drainage basin (simple correlation)*

Table 5. *Regression parameters $I_z=f(d_{75})$*

$I_z = f(d_{75})$			
$y = a\ x^b$			
a=0,471	$S_{(a)}$=0,6468	$t_{(a)}$=-1,1620	$p_{(a)}$=0,2604
b=0,487	$S_{(b)}$=0,1510	$t_{(b)}$=3,2282	$p_{(b)}$=0,0046
R=0,6055	R^2=0,3667		R^2_{cor}=0,3315
F(1,18)=10,421	p<0,0047		S_c=0,5313
$I_z = 0{,}471 \times d_{75}^{0.487}$			

4. CONCLUSION

Analysis of the slope of siltation dependence on grain size composition of sediment has shown that to the given empiric data the best are adjusted regression models in exponential form.

Grain size composition of sediment has a large influence on the siltation slope. Models of siltation slope dependence on the diameter of grain of sediment d_{30}, d_{50}, d_{60} and d_{75} i.e. on size of sediment at 30%, 50%, 60% and 75% share of weight parts on the total weight of sediment are well adjusted to empiric data and they explain well the siltation slope.

Regression analysis in simple models for Trgoviski timok draiage basin has shown that there is a significant correlation between siltation slope and grain size composition of sediment.

LITERATURE

Bilibajkić, S. (2011); Effect of performed technical and biological works of the intensity of erosion processes in the Trgoviski Timok drainage basin, PhD Thesis, The Faculty of Forestry, Belgrade

Kostadinov, S. (1979): Study of anti-erosion action of settling tank as specific type of a dam of Prof. Rosic, in dependence of type of a dam, M.Sc. Thesis, The Faculty of Forestry, Belgrade

Kostadinov, S. (1989): Analysis of formulas for calculating of siltation slope, Forestry, No. 3-4, Belgrade, pp. 3-17

Kostadinov, S. (1996): Torrents and erosion. Serbia. The Faculty of Forestry, Belgrade

Todosijević, M. (2004): Effects of longitudinal objects in torrent streams of Drina river drainage basin in section Loznica-Bacevci, M.Sc. Thesis, The Faculty of Forestry, Belgrade

Velojić, M. (2002): Natural effects of anti-erosion technical facilities in Nisava River drainage basin, Special issues, Endowments Andrejevic, Belgrade