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Quality analysis of surface waters of Rasina district by using the Water Quality Index method

Ljiljana Stričević[1], Ivan Filipović[1], Aleksandar Radivojević[1], Nataša Martić Bursać[1]

[1]*Department of Geography, Faculty of Science and Mathematics, University of Niš*

Abstract: Waters of surface flows of Rasina district are exposed to the influence of numerous pollutants, the most important among which are erosive processes and sediment input into river courses, artificial fertilizers and pesticides used in agricultural production, communal wastewaters of urban and rural settlements, as well as wastewaters of industrial plants in town centers of the district. Consequences of these negative influences are evident on all surface flows in the district where water quality is examined from the part of competent institutions. Most often, water quality does not comply with regulated rates, that is, it clearly deviates from the regulated water quality class II.

This paper analyzes the quality of the waters of surface flows of Rasina district according to the data of the Ministry of Environment on the profile Jasika (Zapadna Morava), Mojsinje (Južna Morava), Varvarin (Velika Morava) and Bivolje (Rasina), in the period from 2001 to 2012. For this calculation we used the data on water quality taken approximately once a month, according to appropriate parameters, by using the Water Quality Index method.

Obtained results show that the waters on all the analyzed profiles are within the limits of class III quality (WQI values from 66 to 71). Linear trend of the change in water quality shows that there is a trend of growth in Water Quality Index values on all the profiles, except in Varvarin on Velika Morava, which indicates the tendency of water quality deterioration on these courses.

Key words: surface waters quality, WQI

1. Introduction

Rasina district is situated in the south part of Central Serbia on the surface of 2668 km^2. The district is bounded by mountain grounds of Goč, Ljukten, Crni vrh and Željin on south-west and west. South-west part of the

[1] Correspondence author: Ljiljana Stričević: ljiljana.s.stricevic@gmail.com
Department of Geography, Faculty of Science and Mathematics, Višegradska 33, 18000 Niš

district is represented by Kopaonik, to which mountain range of Jastrebac is attached east of the river of Blatašnica. Northeast border of the district is represented by Mojsinjske Mountains, while the north border is represented by south slopes of Juhor and Gledićke mountains.

Rasina district includes the parts of the basins of Zapadna Morava, Južna Morava and immediate basin of Velika Morava.

The river of Zapadna Morava runs through the territory of Rasina district, from Trstenik to the confluence with Južna Morava, then the river of Južna Morava, from Đunis to Stalać, and the river of Velika Morava, from Stalać to Obrež. The largest part of the district pertains to the basin of Zapadna Morava – 2023.9 km^2 (75.9% of the total district surface), then to the basin of Južna Morava – 404.8 km^2 (15.2% of the district surface) and the basin of Velika Morava – 239.3 km^2 (8.9% of the district surface).

Waters of the rivers of Zapadna, Južna and Velika Morava are mostly burdened by organic compounds which originate from waste waters from the surrounding settlements which are let off into watercourses without any filtration. Waters from industrial plants also represent a big problem, but their share is significantly smaller compared to communal waters. Waste waters from industrial plants are mostly loaded with nitrogen and phosphorus (Popović et al., 1998). Agricultural soil water erosion, where large amounts of artificial fertilizers and pesticides in agriculture, as well as discharge of organic matters from cattle farms, also largely influence deterioration in the water quality of watercourses. All the above mentioned forms of pollution have become pronounced in the past few years because of draught periods and reduced amount of water in watercourses.

Hitherto water quality analyses in the basin of Zapadna Morava show that quality of the waters of its tributaries is on the crossing between class II and III (Đetinja, Skrapež, Moravica, Bjelica) or class III (Čemernica, Ibar, Rasina). The lowest water quality of the course of Zapadna Morava was recorded on the profiles of Kraljevo and Trstenik, where it is most often on the crossing between class III and IV (Obradović et al., 2009). In the upstream part, near the town of Čačak and Gugaljski Bridge, water quality is better and it pertains to class II and III, as well as in the most downstream profile in Jasika. Regulated water quality class on all the profiles in the basin of Zapadna Morava is II, IIa and IIb (Popović et al., 1998, 2000).

In the basin of Južna Morava waters on all the profiles belong to either class III or class IV. Waters of the lowest quality were registered on the river of Toplica. These waters sometimes come out of the scope of class IV because of excessive pollution (Samardžić, 2013).

Due to such quality state of surface waters on the territory of the whole basin of Velika Morava, it is necessary to constantly analyze and control them. One of the ways to present the state and the trend of water quality change on a certain profile is applying Water Quality Index method, which is based on defining the most important parameters values of which largely influence water quality and reduce them to a certain index number.

Quality analysis of the river waters of Rasina district has been done on the basis of the data of the Ministry of Environment on the profiles of Jasika, Bivolje, Mojsinje and Varvarin in the period from 2001 to 2012, by defining the Water Quality Index (WQI), according to Veljković N. (2006).

2. Methodology of the research

This work uses classification system of describing surface waters quality by using the Water Quality Index (WQI) method, which represents a way of quality assessment of the group of chosen parameters. Water Quality Index (WQI) method uses nine chosen parameters (temperature, oxygen saturation, pH value, nitrogen oxides, phosphates, BPK5, suspended matters, turbidity and coliform bacteria) which in their quality (qi) represent the characteristics of surface waters by reducing them to a certain index number. This value is obtained from the appropriate diagram (curve) for each of the parameters[2] appropriate weight. We took the value for appropriate weight (w_i) for each of the parameters. If we multiply obtained water quality values and the appropriate weight, we get the values sum of which shows the value of Water Quality Index ($\sum q_i w_i$). (Veljković et al., 2007).

To describe obtained results and mark watercourse quality we used the method of quality indicators comparison according to our qualification and the Water Quality Index method. To surface waters quality which corresponds to class I according to our Regulation, WQI method allocates 84-85 points, class II corresponds to 72-78 points, class III to 48-63 points, while class IV corresponds to 37-38 points. Likewise, the values for descriptive quality indicator were adopted: WQI = 0 – 38 very bad, WQI = 39 – 71 bad, WQI =

[2]http://www.water-research.net/index.php/stream-water-quality-importance-of-temperature http://www.water-research.net/index.php/water-treatment/water-monitoring/monitoring-the-quality-of-surfacewaters 25.12.2014.

72 – 83 good, WQI = 84 – 89 very good, and WQI = 90 – 100 excellent (Veljković, 2006).

To analyze water quality by the WQI method on the chosen surface courses on the territory of Rasina district, we used the data of the Ministry of Environment on the chosen profiles of the rivers of Rasina district in the period 2001-2012, taken approximately once a month. On the basis of these data we calculated mean for each measuring point on a yearly level according to the appropriate parameters of the WQI method.

3. Results of the research

Results of the research are shown in tables and line charts. Tables 1-4 show calculated values of WQI for nine chosen parameters, based on their means in the analyzed twelve-year period.

Table 1 - Water Quality Index of Zapadna Morava in Jasika

Parameter	**Value**	**Water quality q_i**	**Weight w_i**	**q_i w_i**
Temperature (^{0}C)	12.4	36	0.10	3.6
Saturation of water with oxygen (%)	105.76	98	0.17	16.66
pH value	8.21	84	0.11	9.24
Nitrogen oxides (mg/ l)	2.24	95	0.10	9.5
Phosphates (mg/ l)	0.09	100	0.10	10
BPK_5 (mg/ l)	2.14	80	0.11	8.8
Dry residue (mg/ l)	257.07	65	0.07	4.55
Turbidity (NTU)	44.82	43	0.08	3.44
Escherichia coli/100 ml	240000	2	0.16	0.32
∑			1.00	66.11

On the basis of the shown procedure of determining Water Quality Index (WQI), obtained value for the river of Zapadna Morava on the profile in Jasika amounts to 66.11, which classifies this river in class III of watercourses according to our categorization. If we used descriptive method to describe water quality of this watercourse, we would classify them as bad quality waters (WQI 39 -71).

Table 2 - Water Quality Index of Rasina in Bivolje

Parameter	**Value**	**Water quality q_i**	**Weight w_i**	**q_i w_i**
Temperature (^{0}C)	11.89	40	0.10	4.0
Saturation of water with oxygen (%)	100.24	99	0.17	16.83
pH value	7.97	88	0.11	9.68
Nitrogen oxides (mg/ l)	2.42	95	0.10	9.5
Phosphates (mg/ l)	0.1	100	0.10	10
BPK$_5$ (mg/ l)	1.80	95	0.11	10.45
Dry residue (mg/ l)	205.73	72	0.07	5.04
Turbidity (NTU)	16.48	66	0.08	5.28
Escherichia coli/100 ml	240000	2	0.16	0.32
∑			1.00	71.1

Obtained WQI values of 71.1 for the profile Bivolje on Rasina classify waters of this river in the category on the crossing between class III to class II, that is, from bad to good waters.

In Mojsinje on Južna Morava defined WQI value of 66.89 classifies its waters in class III waters, that is, bad quality waters.

Table 3 - Water Quality Index of Južna Morava in Mojsinje

Parameter	**Value**	**Water quality q_i**	**Weight w_i**	**q_i w_i**
Temperature (^{0}C)	13.68	34	0.10	3.4
Saturation of water with oxygen (%)	101.68	99	0.17	16.83
pH value	7.94	88	0.11	9.68
Nitrogen oxides (mg/ l)	2.09	95	0.10	9.5
Phosphates (mg/ l)	0.13	100	0.10	10
БПК$_5$ (mg/ l)	2.68	80	0.11	8.8
Dry residue (mg/ l)	233.71	68	0.07	4.76
Turbidity (NTU)	40.59	45	0.08	3.6
Escherichia coli/100 ml	200000	2	0.16	0.32
∑			1	66.89

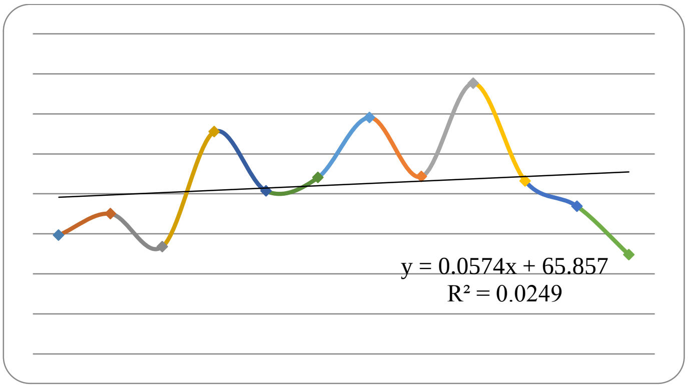
On Velika Morava in Varvarin, as well as in Zapadna and Južna Morava, river waters belong to class III water quality, that is, to waters which can be used for irrigation, possibly for industrial production (except food production), but only after the process of detailed filtration.

Table 4 – Water Quality Index of Velika Morava in Varvarin

Parameter	**Value**	**Water quality q_i**	**Weight w_i**	**q_i w_i**
Temperature (^{0}C)	12.85	36	0.10	3.6
Saturation of water with oxygen (%)	103.93	99	0.17	16.83
pH value	8.25	84	0.11	9.24
Nitrogen oxides (mg/ l)	2.3	95	0.10	9.5
Phosphates (mg/ l)	0.11	100	0.10	10
БПК$_5$ (mg/ l)	2.47	80	0.11	8.8
Dry residue (mg/ l)	251	66	0.07	4.62
Turbidity a (NTU)	139.29	5	0.08	0.4
Escherichia coli/100 ml	200000	2	0.16	0.32
∑			1	63.31

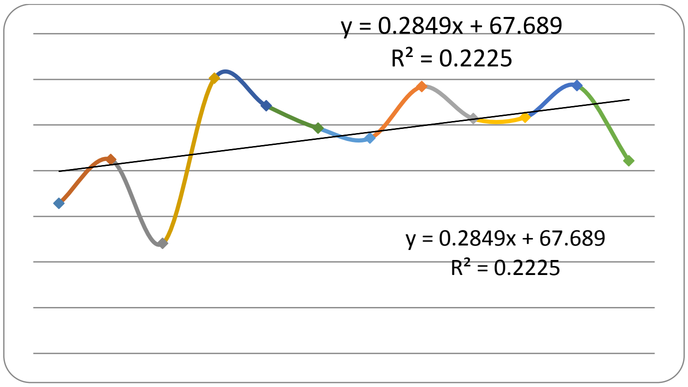
Shown values of the parameters used to analyze water quality in the period 2001-2012 were related to their means for the given period. Water quality is not a fixed category and it is influenced by a number of factors .Some of these factors are lasting and change slowly in time, while others appear suddenly, without any order and disturb the existing state of water quality. These factors can represent unexpected seasonal hydrologic changes, or sudden, often accidental, discharge of large amounts of waste waters in watercourses, which briefly disturbs their existing quality (Stričević, 2015).

For all the analyzed profiles in Rasina district yearly values of Water Quality Index (WQI) and their linear correlation were determined and shown in charts 1-4. On the basis of these charts it is possible to observe the tendency of change in water quality in the analyzed period.



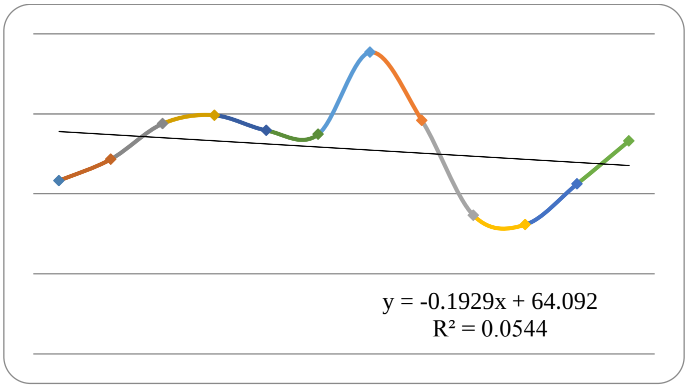
Graph 1 - Linear trend of the change in water quality of the river of Zapadna Morava in Jasika station,
in the period 2001-2012 expressed using WQI method

When analyzing charts on water-meter station Jasika on Zapadna Morava we can perceive linear trend showing average WQI value of 65.85 in the reference period, while average growth in each year amounted to 0.057 index points.



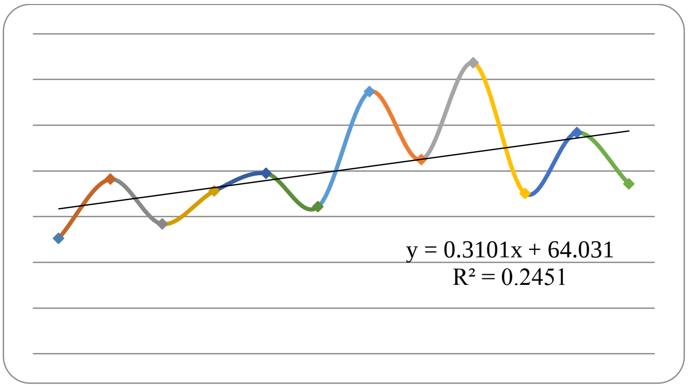
Graph 2 - Linear trend of the change in water quality of the river of Rasina on Bivolje station,
in the period 2001-2012 expressed using WQI method

Average WQI value in the reference period on Bivolje station amounted to 67.68, while average growth in each year amounted to 0.28 index points.



Graph 3 - Linear trend of the change in water quality of the river of Velika Morava on Varvarin station,
in the period 2001-2012 expressed using WQI method

Average WQI value in the reference period on Varvarin station amounted to 64.09, while average drop in each year amounted to 0.19 index points.



Graph 4 - Linear trend of the change in water quality of the river of Južna Morava on Mojsinje station,
in the period 2001-2012 expressed using WQI method

Average WQI value in the reference period on Mojsinje station amounted to 64.03, while average growth in each year amounted to 0.31 index points.

4. Discussion

Obtained values of mean Water Quality Index (WQI) during several years on the analyzed profiles of the rivers of Rasina district show that those waters mostly belong to class III water quality.

In the analyzed twelve-year period on Zapadna Morava in Jasika the lowest WQI value of 64.78 was registered in 2012, while the highest value was registered in 2009 – 68.76. 2009 was the year of very low water levels on this profile. On the basis of the above mentioned values, we can say that the waters of Zapadna Morava in the most downstream part of the course were of bad quality in this period.

The lowest WQI value of 64.81 was registered in 2003 on the river of Rasina in Bivolje, while the highest value was registered in 2004 – it amounted to 72.05. These results show that the waters of Rasina River at its confluence to Zapadna Morava are on the border between bad and good waters.

The lowest WQI value of 58.07 was registered in 2010 on the river of Velika Morava in Varvarin, while the highest value was registered in 2007 – it amounted to 68.85, which indicates bad quality of waters of this river in its most upstream part.

On Južna Morava in Mojsinje the lowest WQI value of 63.04 was registered in 2001, while the highest value was registered in 2009 – it amounted to70.72, which also indicates bad quality of waters of this river in its most downstream part.

On the basis of the shown linear correlation we can conclude that there is a trend of growth of Water Quality Index value in all of the profiles except the one in Varvarin, which indicates the tendency of deterioration of water quality in these watercourses.

Water quality analysis by using Water Quality Index (WQI) method enables a comprehensive approach of surface waters quality state through analyzing the most important parameters. It also enables analyzing the trend in the change of water quality, which can be a basis for more detailed analysis of the cause of pollution of surface waters and defining guidelines and activities in the process of water protection. Apart from using numerical mode, results of water quality analysis can be shown in a descriptive way, that is, using descriptive indicator. Descriptive indicator is, above all, useful for informing the population on water quality, namely on the possibilities of using those waters for certain purposes. This index does not have numerical values, but its description was derived on their basis.

References

Dokumentacija Ministarstva za zaštitu životne sredine, Kvalitet voda, 2001-2012., Beograd

Obradović D., Filipović D. Analiza kvaliteta površinskih i podzemnih voda na teritoriji grada Kraljeva – osnov za održivo upravljanje vodnim resursima, Glasnik SGD, 2009, LXXXIX.4; 201-214

Popović V., Petrović P., Brković P. Emisija zagađenja iz skoncentrisanih izvora u slivu Velike Morave, Zbornik radova „Vodni resursi sliva Velike Morave i njihovo korišćenje*“.1*998, 107-116.

Popović V., Petrović P., Brković P.. Uticaj načina korišćenja zemljištaa na zagađenje voda u slivovima Zapadne Morave i Rasine na teritoriji opštine Kruševac. Zbornik radova „Vodni resursi sliva Velike Morave i njihovo korišćenje“, 2000. 140-145.

Samardžić M., Vremensko i prostorno rasprostranjivanje zagađivača u slivu Velike Morave, Doktorska disertacija, Poljoprivredni fakultet, Univerzitet u Novom Sadu, 2013

Stričević LJ. Vodni resursi Rasinskog okruga i njihov uticaj na regionalni razvoj, Doktorska disertacija, Prirodno-matematički fakultet, Univerzitet u Nišu, 2015

Veljković N. Inikatori održivog razvoja i upravljanje vodnim resursima, Zadužbina Andrejević, 2006

Veljković N., Jovičić M. *Analiza kvaliteta Dunava kroz Srbiju metodom* Water Quality Index, Zborniku referata konferencije „Voda 2007, JDZV i Institut „J.Černi“, 2007.

http://www.water-research.net/index.php/stream-water-quality-importance-of-temperature, 25.12.2014.

http://www.water-research.net/index.php/water-treatment/water-monitoring/monitoring-the-quality-of-surfacewaters 25.12.2014.

Hydrological forecasts of average, low and high waters in the Gaberska River Basin

Mrđan Đokić[1], Nenad Živković[2], Ninoslav Golubović[1], Milena Nikolić[1], Ranko Dragović[1]

[1]*University of Niš, Faculty of Sciences and Mathematics, Department of Geography*
[2]*University of Belgrade, Faculty of Geography*

Abstract: Gaberska River is distinguished by its torrential character, which is conditioned by the geological structure of the basin, degraded forest cover, unregulated course of the main river and its tributaries and others. In this paper, the quantification of the average, minimal and maximal annual discharges was done, as well as the forecast of the probability of their occurrence based on forty-four-year measurements. The Log Pearson III distribution method was used, and the return period of the occurrence of discharges expressed in years was determined, i.e., the probability of occurrence was expressed in percentages. The results confirmed the torrential character of the Gaberska River and great fluctuations in discharges during the research period. The measures for mitigation of high and low waters have been proposed.

Key words: Gaberska River, discharge, hydrological forecasts, Log-Pearson III

1. Introduction

The Gaberska River Basin covers the border area of the Republic of Serbia and the Republic of Bulgaria, limited by the basins of the Jerma River in the west, Ežovica River in the east and the Slivniška River in the southeast. The Gaberska River is the left tributary of the Nišava River, and by the length of 40.51 km, the basin area of 249.2 km^2, is its most important tributary upstream from the confluence of the Jerma River.

Average discharge of the Gaberska River in the period from 1964 to 2007 was 1.06 m^3/s, which gave the runoff of 4.25 l/s/km^2. This value is the lowest compared to other major tributaries of the Nišava River, including the Nišava River itself, which has an average runoff of 7.09 l/s/ km^2 (Djokić, 2015). Such low value is more surprising considering that the water richness, expressed through runoff, generally increases upstream (Dukić, Gavrilović, 2008). In the case of the Gaberska River, the runoff is low considering the low average altitude of the basin area of 742 m (which is lower value even compared to the average altitude of the Nišava River Basin - 813 m), and in this regard, also the small amount of precipitation. Eastern position of the Gaberska River Basin within the Nišava River Basin also affects the reduced amount of precipitation, and the human impact through irrigation should not be ignored.

Few authors have done the research of the hydrological characteristics of this river basin so far. The torrential character of the Gaberska River was pointed out by Djokić M. (2015) and explained, before all, by a geological assembly of the terrain that was composed mainly of impermeable rocks and which was characterized by low capacity of groundwater, mainly degraded forest cover, unregulated river courses and steep inclines of the tributaries.

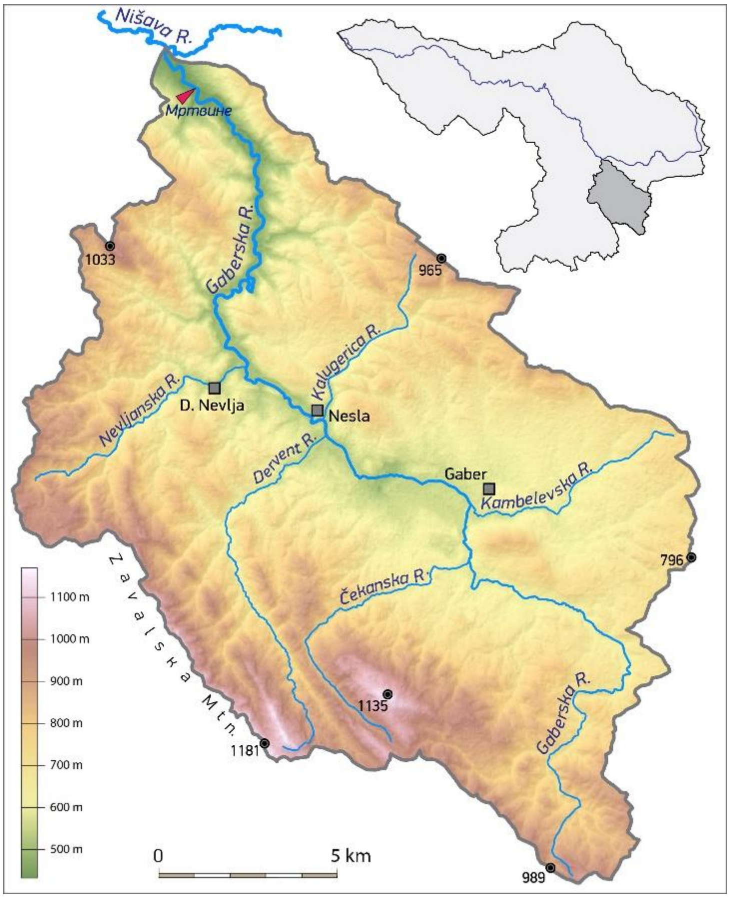


Figure 1 – Gaberska River Basin and its location within the Nišava River Basin

The aim of this paper will be the quantification of the average, minimal and maximal annual discharges and the forecast of the probability of their occurrence, which will facilitate the water management planning in the Gaberska River Basin.

2. Material and method

River discharges depend on a huge number of various factors and are subject to the laws of coincidences, so they can be studied by the use of the statistical methods (Gavrilović, 1988). Assessment of the size of discharges which can be expected in the future on a certain hydrological profile, can be given on the basis of the value of the discharges that have already occurred. In other words, it is necessary to determine the return period of occurrence of a discharge, expressed in years, i.e., the probability of its occurrence, expressed as a percentage.

In order to make a reliable estimate of the discharges, it is necessary to take into account a longer series of data. This paper analyses the data on the average annual, minimal and maximal annual discharges for the period from 1964 to 2007, which were measured at the hydrological station of Mrtvine, near the confluence of the Gaberska River in the Nišava River. Among many statistical methods for forecasting the size of the discharges, the Log Pearson III distribution is often used. This distribution is widely applied and used in a number of hydrological studies (Bob, 1975; Wallis, Wood 1985, Gavrilović, 1988; Milanović, 2006; Griffis, Stedinger, 2007; Djokić, 2010; Bolgov, Korobkina, 2013; Vasilevski, Radevski 2014). It was even recommended by the US Water Resources Council (WRC).

The process of the discharge forecasting firstly involves the calculation of the average value of the discharges for the given period, or Q_{av}. After that, the module coefficient *k* is calculated for each value of the annual discharge, by dividing with the average value of the entire series, or $k = \frac{Q}{Q_{sr}}$.

The coefficient of variation of the discharges which places in relation the average deviation and the arithmetical mean of the series of measurements, as well as asymmetry coefficient are calculated in further method procedure.

To avoid getting negative values of the discharges, it is often assumed that $C_s=2C_v$, which is applied on this occasion as well. In the table of Ribikin (Gavrilović, 1988), for each value of the asymmetry coefficient is given a deviation of the ordinate of the binominal asymmetric curve of provision from the average at C_v=1 (ø), and the parameters for design of the curve of provision from the average annual discharges are calculated (Gavrilović, 1988). The result is the estimation of the probability of the discharge occurrence, expressed as a percentage from 0.01% to 99.9%, as well as an assessment of the discharge occurrence expressed in years, from one year (discharge can be expected each year) to 10,000 (discharge is expected once in 10,000 years).

Table 1 – Parameters for calculating the curve of provision of the average annual discharges and the probability of the occurrence of the average annual discharges of the Gaberska River in Mrtvine

Probability (%)	Probability (years)	ø	ø·C_v	K_s = ø·C_v+1	$Q_{av.}$ (m^3/s)
0.01	10,000	5.62	2.44	3.44	3.64
0.1	1,000	4.31	1.87	2.87	3.04
1	100	2.92	1.27	2.27	2.40
3	33.3	2.2	0.95	1.95	2.07
5	20	1.85	0.80	1.80	1.91
10	10	1.34	0.58	1.58	1.68
20	5	0.78	0.34	1.34	1.42
25	4	0.58	0.25	1.25	1.33
30	3.3	0.4	0.17	1.17	1.24
40	2.5	0.12	0.05	1.05	1.12
50	2	-0.14	-0.06	0.94	1.00
60	1.67	-0.38	-0.16	0.84	0.89
70	1.42	-0.6	-0.26	0.74	0.78
75	1.33	-0.73	-0.32	0.68	0.72
80	1.25	-0.86	-0.37	0.63	0.66
90	1.11	-1.16	-0.50	0.50	0.53
95	1.05	-1.35	-0.59	0.41	0.44
99	1.01	-1.7	-0.74	0.26	0.28
99.9	1,001	-1.96	-0.85	0.16	0.16

ø – deviation of the ordinate of the binominal asymmetric curve of provision from the average at C_v=1, $\mathbf{C_v}$ – coefficient of variation of the average annual discharges, $\mathbf{K_s}$ – module coefficient of the ordinate, $\mathbf{Q_{av.}}$ **–** average discharge for the given occurrence probability

As an example for the procedure, Table 1 shows all the parameters for the estimation of the average annual discharges of the Gaberska River in Mrtvine. Table 2 shows only the estimated minimal and maximal discharges. The presented method can be also applied to determine the probability of a discharge occurrence on a monthly basis.

3. Results

Once every 10,000 years, the average annual discharge of 3.64 m^3/s of the Gaberska River can be expected, once in 1,000 years of 3.04 m^3/s and once in 100 years of 2.4 m^3/. Only once in 10,000 years, the average annual discharge could be below 0.16 m^3/s. The lowest measured value of the average annual discharge was 0.33 m^3/s, and was recorded during the least water richness year of 1993. The highest average annual discharge was recorded in 1976 and amounted to 2.03 m^3/s, and the probability of its occurrence is slightly higher than 3%, or once in 33 years.

The average annual discharge of the Gaberska River at Mrtvine is 1.06 m^3/s, and at least that same discharge can be expected, with a probability of about 48%, which is exactly what happened for twenty two of the forty-four-year study period. The coefficient of variation of the average annual discharges of the Gaberska River at Mrtvine is 0.43.

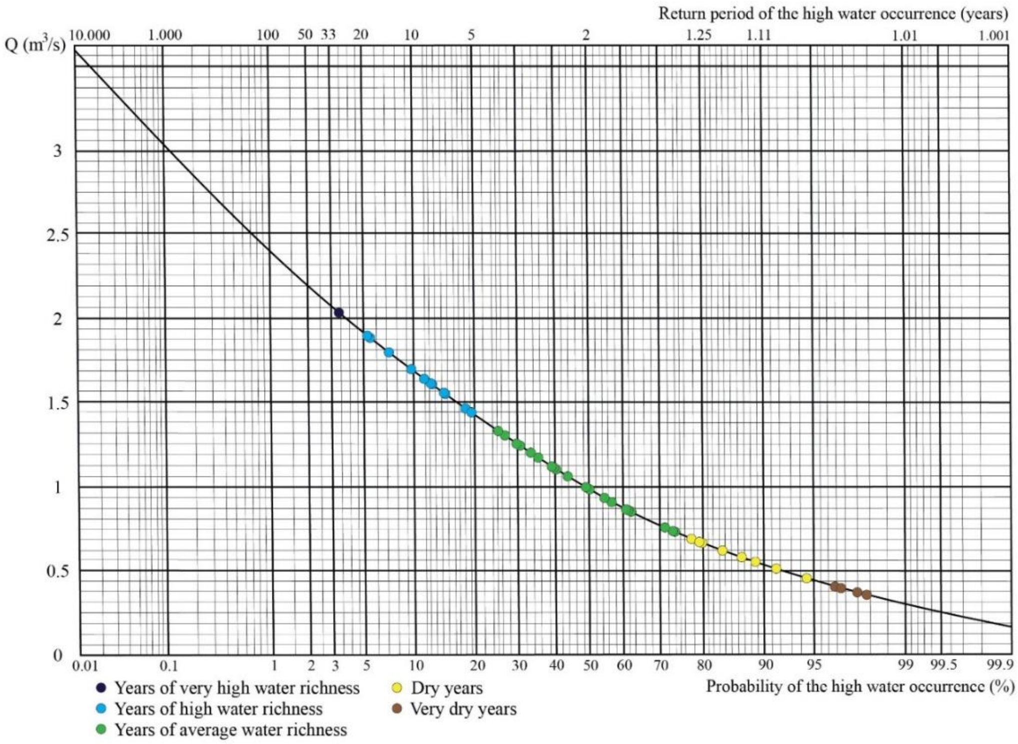


Figure 2 – Curve of the occurrence probability of the average annual discharges of the Gaberska River in Mrtvine

In the period from 1964 to 2007, the average value of the minimal annual discharges of the Gaberska River at Mrtvine amounted to 0.21 m^3/s. Every year we can expect a discharge of at least 0.005 m^3/s, and every other year of at least 0.14 m^3/s. The highest minimal discharge was recorded in 1981, the fourth year in regard to water richness in the research period, and amounted to 1.18 m^3/s. The lowest recorded discharge during the period covered by the researches is 0.023 m^3/s, during the least water richness year of 1993 (July 21st).

Table 2 – Occurrence probability of the minimal and maximal discharges of the Gaberska River in Mrtvine, in m^3/s

Probability (%)	Probability (years)	$Q_{min.}$	$Q_{max.}$
0.01	10,000	1.97	229.9
0.1	1,000	1.51	176.0
1	100	0.99	119.5
3	33.3	0.75	92.6
5	20	0.64	79.6
10	10	0.49	62.5
20	5	0.34	44.9
25	4	0.29	38.9
30	3.3	0.25	34.3
40	2.5	0.19	26.7
50	2	0.14	21.0
60	1.67	0.10	15.9
70	1.42	0.07	11.7
75	1.33	0.06	9.6
80	1.25	0.05	7.6
90	1.11	0.02	4.2
95	1.05	0.014	2.4
99	1.01	0.007	0.8
99.9	1	0.005	0.3

Coefficient of variation of the minimal annual discharges of the Gaberska River at Mrtvine is 1.02, which is very high value.

The average value of maximal annual discharges of the Gaberska River in Mrtvine is of 28.3 m^3/s. In the period covered by the research, the maximal discharge was recorded on July 1st, 1983. This year is otherwise characterized by an average water richness. At that time, through a riverbed of the Gaberska River, 104 m^3/s was discharged. The probability of the occurrence of so much discharge is about once in 60 years.

The minimal value of the maximal annual discharge is 3.19 m^3/s and was recorded in a dry year of 1990. Once every 10,000 years a discharge of 229.9 m^3/s can be expected at Mrtvine, and every other year, the maximal discharge of at least 21 m^3/s. The coefficient of variation of the maximal annual discharges of the Gaberska River in Mrtvine is high - 0.92.

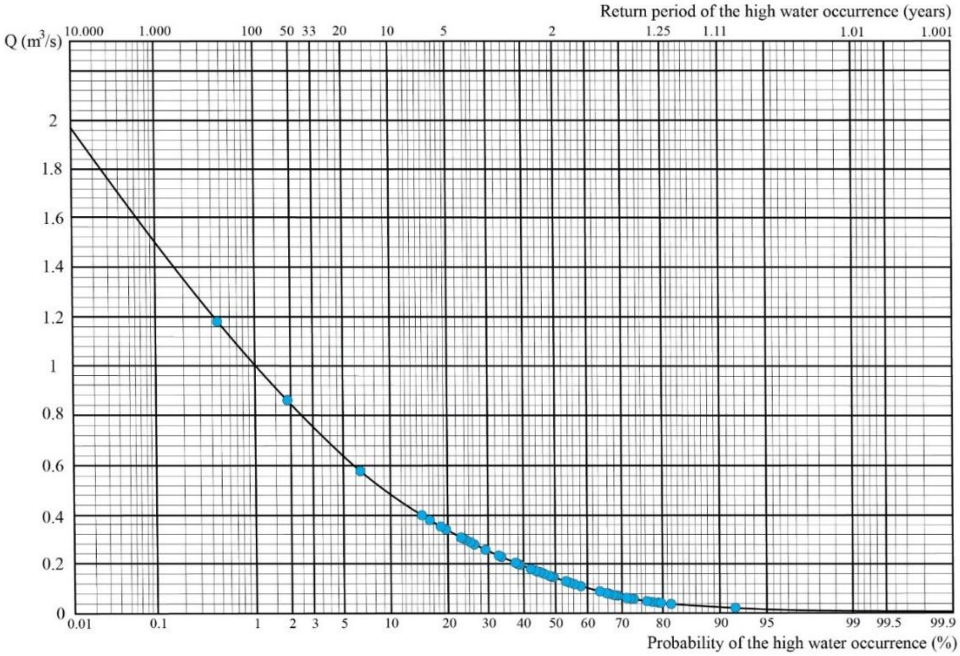


Figure 3 – Curve of the occurrence probability of the minimal annual discharges of the Gaberska River in Mrtvine

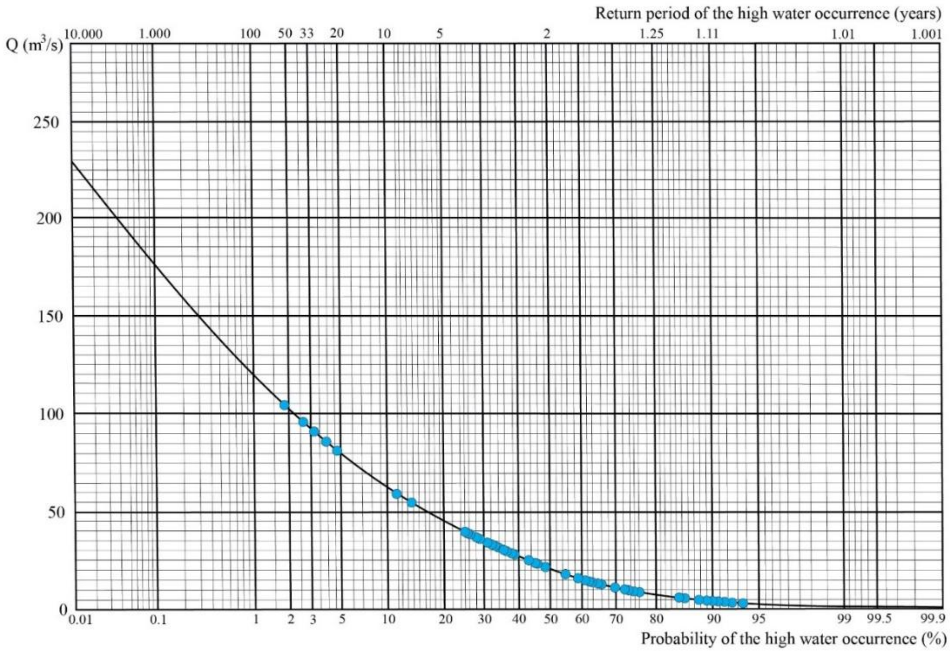


Figure 4 – Curve of the occurrence probability of the maximal annual discharges of the Gaberska River in Mrtvine

4. Discussion

Gaberska river is of a torrential river course, as confirmed by the Log-Pearson III distribution. The coefficient of variation of the average annual discharges is 0.43, which is a value that indicates significant fluctuations in discharges. This value is higher than those recorded in the downstream profiles of the Nišava River (0.33 in Pirot, 0.31 Bela Palanka and 0.31 in Niš), but is in accordance with the values of the neighbouring hydrological station in Dimitrovgrad - also 0.43 (Djokić, 2015). There are large fluctuations in discharges are on a monthly basis as well. The highest coefficients of variation are during the cold moths of January (1.08) and February (0.94) because, on the one hand, the precipitation often linger in the form of snow cover and in that way reduce discharges, while on the other hand, sudden warming cause snow to melt, what leads to increasing discharges. Also, a large coefficients of variation in discharges are recorded in July (C_v=1.05), August (C_v=1.03), September (C_v=0.95) and October (Cv=1), when the normally low discharges sometimes increase because of heavy precipitation.

The coefficient of variation of the minimal annual discharges is expectedly even higher, and amounts to 1.02, indicating extreme fluctuation. The ratio of the highest and the lowest recorded minimal annual discharges is 1:51.3. In the observed forty-four-year period, the minimal discharges are usually recorded in August (18 times) and September (11 times) as a result of high temperatures and lesser amount of precipitation.

The coefficient of variation of the maximal annual discharges is 0.92, that is, the fluctuations are extreme. The ratio of the highest and the lowest recorded maximal annual discharges amount to 1:32.6. The maximal annual discharges are more regularly distributed throughout the year than the minimal ones. The most common are recorded in March (8 times), April and February (7 times) and in May and June (5), which was caused by a period of heavy precipitation, rapid snowmelt period, or the overlapping of these two periods.

The Gaberska River discharges are characterized by large fluctuations. The ratio of the absolute maximal and absolute minimal discharge, during the period of observation covered by this study, amounts to 1:4522. Extremely large discharges in relation to its average value can be expected. Thus, once in 1,000 years, a discharge that is even 166 times higher than the average can be expected. On the other hand, once in 1,000 years, a discharge can fall to the value of 151 times lower than the average annual value.

Extreme fluctuation in discharges of the Gaberska River complicates the water management planning. In order to mitigate the effects of high waters, it is necessary to take measures which would include planning of the reforestation of the basin area, regulation of the river course in the form of its straightening, widening of the riverbed and cleaning of sediments, the construction of reservoirs for high waters. Low waters, among other things, are a consequence of the relatively high population density by rural population, who, by using both groundwater, and river water for irrigation, can easily reduce the already low discharges during the dry period of the year. It is necessary to legally regulate this area and exercise control of individual irrigation. Reservoirs can also be used to mitigate the effects of low waters.

References

Bobée B. The Log Pearson Type 3 Distribution and Its Application in Hydrology, Water Resources Research 1975, Vol. 11, No. 5

Bolgov M, Korobkina E. Applying the Log Pearson Type 3 Distribution for Modeling Annual Inflow to the Closed Lake, Water & Environmental Dynamics, 6th International Conference on Water Resources and Environment Research, Koblenz, Germany, 2013

Gavrilović Lj. Hydrology in Spatial Planning, Department of Geography and Regional Planning of the Faculty of Science and Mathematics 1988

Griffis V. Stedinger J. Log-Pearson Type 3 Distribution and Its Application in Flood Frequency Analysis. I: Distribution Characteristics, Journal of Hydrologic Engineering 2007, Volume 12, Issue 5

Dukić D. Gavrilović Lj. Hydrology, Textbook Institute, Belgrade 2008

Đokić M. The Nišava River – Potamology Study, Doctoral Dissertation. Faculty of Science and Mathematics, University of Niš 2015

Đokić M. Hydrogeographical Study of the Jerma River, Master's Thesis. Faculty of Geography, Belgrade 2010

Milanović A. Hydrological Forecast of High Waters in the Lepenica River Basin and Flood Protection, Bulletin of the Serbian Geographical Society 2006, 1:47-54

Vasilevski D, Radevski I. Analysis of High Waters on the Kriva reka River, Macedonia. Acta geographica Slovenica 2014, 54-2

Wallis J. Wood E. Relative Accuracy of Log Pearson III Procedures, Journal of Hydraulic Engineering 1985, Volume 111, Issue 7

Preliminary geochemical investigation of agricultural soil from Eastern Serbia (Sokobanja Basin)

M. G. Djordjević[1], D. M. Djordjević[1], M. A. Pavlović[2], S. B. Tošić[3], M. B. Mirić[4]

[1]*Laboratory for Geochemistry, Cosmochemistry and Astrochemistry, University of Niš, Serbia*
[2]*Faculty of Geography, University of Belgrade, Serbia*
[3]*Department of Chemistry, Faculty of Science, University of Niš, Serbia*
[4]*Directorate of Measures and Precious Metals, Mike Alasa 14, Beograd, Department of the control subjects in precious metals, Generala Boze Jankovica 32, Niš, Serbia*

Abstract: The origin of heavy metals in living environment is different and rough division can be made into geogenic and anthropogenic. On and in soil heavy metals arrive through acid rain, dust, and carbon black. Into the layer of soil that has been used for agriculture, so called plough land, heavy metals come through plants that suck them in from deeper layers, and thus deposit them in more shallow layers. The most significant anthropogenic sources of soil pollution with heavy metals are motor vehicles, metal industry, mines and metal smelter, organic and mineral fertilizers. The aim of this study is to determine the content of heavy metals in agricultural land Sokobanja basin. The analysis results show that dissolubility of the tested samples goes from 19.1% to 31.8% for the samples from the soil surface, and from 17.8% to 30.4% for the samples from 30 cm depth. FTIR analysis determines lower contents of the carbonate minerals in comparison to the silicate minerals, and that is confirmed with stereomicroscopy. Based on the results gained from ICP analysis it can be concluded that most of the soil from the tested area is safe for agriculture usage.

Keywords: soil, heavy metals, Sokobanja, fractionation, ICP analysis.

1. Introduction

Sedimentary rocks are being created by deposition of solid material in water environment, where organic and/or non-organic substance existed in the form of suspension or dissolution, under the moderate temperature and pressure. The process of sediments creation lasts for a very long time and it is being carried out through more or less separate processes: decomposition of the primal rocks, transfer and deposition of the material created in that manner, transformation of the sediments into the firm rocks or deposition and post deposition processes (physical/chemical changes on the sediment).

The initial material for sediments creation comes from igneous and metamorphic rocks, after their erosion and denudation (Nesse, 2000). The process of igneous and metamorphic rocks creation is very long and comprises the following: erosion of the igneous and metamorphic rocks caused by water, ice, wind, climate and temperature changes; transportation of the material in solid or liquid state or in the form of resolution; settling (sedimentation, deposition) that occurs when the energy of the transport environment is too low to allow transportation process, and digenesis that includes all processes of sediments conversion into the solid rocks.

Based on predominant type of physical, chemical, biochemical and geological processes sediment rocks are being divided into: Exogenous (classical, detrital) rocks created by physical and chemical deterioration, especially through other rocks physical degradation, and during that period created particles are physically deposited after longer or shorter transport, and Endogenous rocks that are created by amorphous or crystal sedimentation from resolution as well as by biochemical processes. However, greatest part of the sediments is of the polygenetic origin, which makes their qualification difficult.

Sediment rocks contain very important information about Earth history, where differences between neighboring layers indicate changes of the sedimentation environment as well as atmosphere, hydrosphere and tectonic changes that happened over time. They also contain fossils; since contrary to the igneous and metamorphic rocks, they are being created at the temperature and pressure that does not destroy fossil remain.

The importance of these rocks comes from the fact that roughly, 85 - 90 % of all mineral raw materials are derived from sediment rocks, and only 10 - 15 % is derived from igneous and metamorphic rocks (Goldschmidt, 1937). Basic characteristics of sediment rocks are layering, porosity, and transmission. These very characteristics are responsible for frequent occurrence of the sediment rocks as a reservoir of the natural gas, oil, and mineral water. The most present sediment rocks are sandstones, limestone, and bituminous shale**.** They comprise roughly 95 % of all sediments (Pettijohn, 1983).

The origin of heavy metals in living environment is different and rough division can be made into geogenic and anthropogenic. In the form of fine dust particles, heavy metals can get to the atmosphere where they continue to deposit in water (carbonates that are difficult for solution, sulphates or sulphides that are being deposited at the bottom) and in soil. On and in soil heavy metals arrive through acid rain, dust, and carbon black (Efe, 2010). Into the layer of soil that has been used for agriculture, so called plough land, heavy metals come through plants that suck them in from deeper layers, and thus deposit them in more shallow layers. The most significant anthropogenic sources of soil pollution with heavy metals are motor vehicles, metal industry, mines and metal smelter, organic and mineral fertilizers.

Heavy metals connect to the adsorption complex in the soil or can be found in the form of ions within the soil resolution, and in both forms they are available for plants. The sorption ability of a heavy metal ion depends more from the form in which occurs in the soil than its quantity (Kabata-Pendias *et al.* 2001, Pierzynski *et al.* 2000).

Heavy metals naturally exist in the soil mostly in complexes with other minerals (Kabata-Pendias *et al.* 2001, Pierzynski *et al.* 2000). Cation metals (in the soil they exist in the form of a positively electrified cation for ex. Pb^{2+}) as well as mercury, cadmium, lead, nickel, copper, zinc, chrome, and manganese mostly cause the problems. Most common anion chemical compound (in combination with oxygen, for example negatively electrified MoO_4^{2-}) are arsenic, molybdenum, selenium and boron (Alloway 2013, Hu, 2013).

Sokobanja (SB) basin is situated about 60 km north from Niš (Figure 1) and its surface is 250 km^2. Sokobanja basin is a tectonic depression placed in the direction north-south, 29 km long and 16 km wide. The basin is filled with 1500m thick layer of limestone sediment, deposited in the time interval from lower Paleogene until upper Miocene, and thus a typologically very versatile soil was created in the Sokobanja area (Radivojević, 2008).

2. Materials and methods

20 samples have been tested from the Sokobanja basin. (Figure 1). This samples have been collected along the Moravica river flow and marked: A (1-

10) samples from the soil surface and B (1-10) samples taken at the depth approximately 30 cm.

Table 1. Soil type in SB basin

Soil type	Surface (ha)	%
Smonitsa	6800	12.9
Eroded smonitsa	1200	2.8
Smonitsa in limiting	4700	8.9
Smonitsa loessivized	1400	2.7
Smonitsa alluvial-meadow soil	400	0.8
Rendzina on limestone	1600	3.0
Brownised rendzina and brown soil on limestone	15437	29.3
Brown soil on limestone	2200	4.2
Brown loessivized soil	600	1.2
Red land in Permian sandstone	1300	2.5
Brown skeletal soil on phyllites	5000	9.5
Brown skeletal soil on phyllites with quartzite	500	0.9
Brown shallow skeletal soil on sandstone	2400	4.6
Brown soil on andesite	600	1.2
Parapodzol	400	0.8
Alluvium loamy	1200	2.8
Delluvium	1100	2.1
Skeletal soil on limestone	5200	9.8
Skelet- rocky ground	600	1.2
Total	52 637	100

Figure 1. Geographical location of the SB samples

Moist soil samples have been shaken on plastic plates and recorded in the soil samples book, where a laboratory number was given to each. The samples have been finger crunched until pieces 1 – 3 cm big were made and left to be air-dried. After drying, the samples were grinded in a soil mixer that works on a principle of two sliding plates, sifted and placed in boxes with a laboratory number.

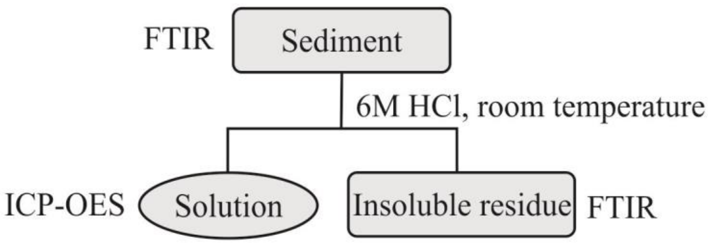
1. *Fractionation procedure.* Before treatment with mineral acids, the samples were grinded in a vibrating mill to particle size of 100 μm. The fractionation procedure was similar to that used by Premović *et al.* 2000. The flow chart in Figure 2 outlines the major steps in preparing the two fractions of samples from SB basin.
2. *Dilution in hydrochloric acid*. The insoluble residue was demineralized further by repeated treatment with cold 6 M HCl. This acid solution removed mostly metal oxides. After rinsing and drying, the remainder was measured and determined by the fractions soluble in cold HCl. The soluble material constitutes the fraction of metal oxides and hardly soluble carbonates.
3. 

Figure 2. *Flow chart of fractionation procedure*

4. *Fourier Transform Infrared (FTIR) Spectrometry.* FTIR spectra were recorded, in absorbance mode, with a BOMEM Michelson Series MB FTIR spectrometer set to give undeformed spectra. The resolution was 4 cm^{-1} in the 400-4000 cm^{-1} analyzed range. Spectra were obtained at room temperature from KBr pressed pellets prepared by mixing 1.5 mg of a clay sample with 150 mg of KBr.
5. *Inductively coupled argon plasma (ICP).* The concentrations of metal ions dissolved from the rest (Todorović, 1997, Kerovec, 2010) are determined ICP-Optical Emission Spectrometer iCAP 6000 Series, Thermo Scientific, Cambridge, United Kingdom. Analysis was used Multi Standard -Ultra Scientific Analytical Solutions, USA.

3. Results and discussion

pH. pH values for all samples were also determined and they vary, as it can be seen in the Table 2, from 5.12 to 7.30, for the surface samples A and from 5.17 up to 7.47 for the samples taken from the depth B.

Table 2. Results of measuring pH of the soil from SB basin

Sample	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10
pH	*6.14*	*6.91*	*7.21*	*7.30*	*7.26*	*7.26*	*6.67*	*6.74*	*5.12*	*7.13*
Sample	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9	B-10
pH	*6.74*	*7.04*	*7.33*	*7.30*	*7.26*	*7.47*	*6.61*	*6.74*	*5.17*	*5.89*

Stereomicroscopy. Stereo-micro photos (taken with stereomicroscope "Krüss" and taken with "Nikon 4500" camera) of the fine grinned raw (Figure 3A) and sample treated with hydrochloric acid (Figure 3B) show that the material is homogenous. Stereo images confirm the results of the FTIR analysis – indicate lesser presence of the carbonate in comparison to the silicate material, as well as the absence of the organic substance.

A

B

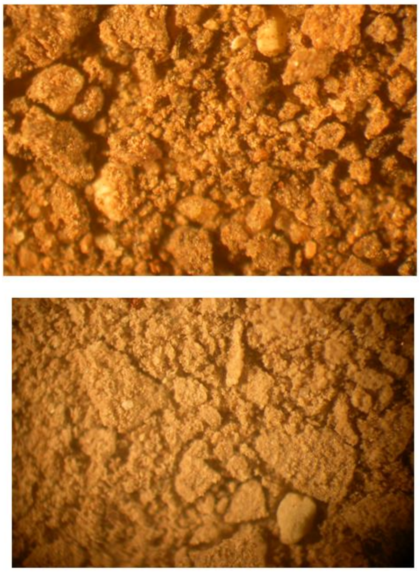


Figure 3. *Stereo microphotography (180 × magnification:) A) untreated sample and B) sample of SB treated with hydrochloric acid*

Fractionation procedure. Dissolubility of the soil samples was tested. Dissolubility values (Table 3) go from 19.1% to 31.8% for the samples from the soil surface (samples A) and from 17.8% to 30.4% for the samples taken at the depth out of 30 cm (samples B).

Table 3. Results solubility of soil samples from SB basin

ample	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
olubility (%)	*1.8*	*9.2*	*0.2*	*4.8*	*8.2*	*0.0*	*9.2*	*6.0*	*9.1*	*2.2*
ample	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
olubility (%)	*0.3*	*7.8*	*2.8*	*0.4*	*3.0*	*0.2*	*3.0*	*3.1*	*1.5*	*9.7*

FTIR. Analysis by sequential demineralization shows that the samples taken from the Sokobanja basin are partially dissoluble in cold/hot water HCl (up to 31.8 %) which indicates absence of carbonate minerals as well as organic matters, implying the presence of the silicate minerals.

FTIR spectrum of the untreated samples 1, 2 i 3 are presented on Figure 4. Spectrum of all samples is very similar so the mentioned ones were the only presented.

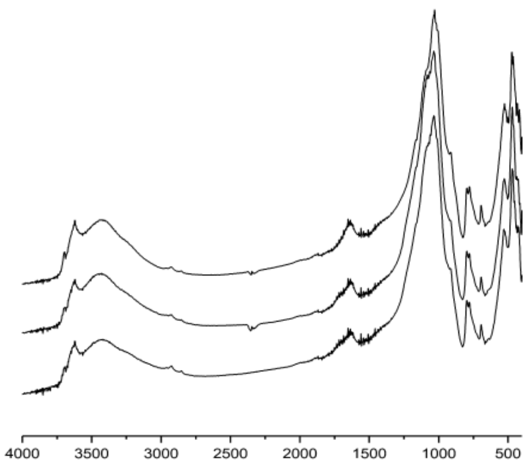


Figure 4. *FTIR spectra of untreated SB samples*

Presented spectrum shows domination of the inorganic fraction stripes in comparison to the organic.

FTIR samples spectrum dominating inorganic fraction tapes are those at about 1615, 875 and 712 cm^{-1}, they are characteristic for carbonate minerals, especially calcite with admixture of aragonite as well as at 3623, 1095, 1030, 920, 789, 777, 527, 470 and 417 cm^{-1} characteristically for silicate matters (Madejova, 2003).

Tape at 1031 cm^{-1} (coming from Si and Si-Al mineral) is the most dominant in the spectrum and based on relative intensity of that tape we could say that Si and Si-Al minerals are the most common ones. This corresponds to the fraction analysis data of the inorganic fractions where carbonate fraction (remaining after the cold/hot water treatment HCl) is present in this sample 30 %, and silicate up to 70%, as well as with data that agricultural soil in this part of Serbia is mostly sandy soil type.

Because of the insufficient division of these tapes, it is almost impossible to determine minerals responsible for this tapes occurrence. However, it can be said that these tapes surely generate from the Si/ Si-Al minerals and according to that, it is possible to give short list of the most probable ones, which are:

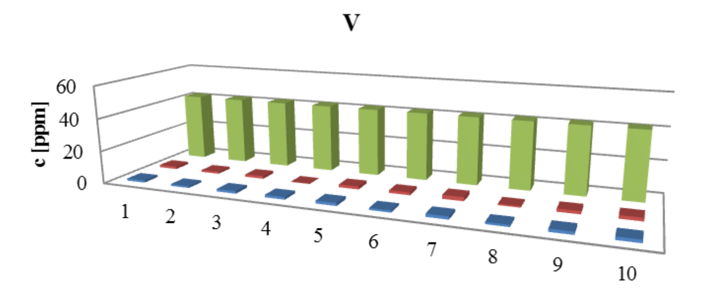
- montmorillonite
- illite
- secundary aluminous chlorite
- interstratified montmorillonite/illite
- interstratified montmorillonite/chlorite
- cristobalite
- quartz.

From the mentioned Si/Si-Al minerals the most present are secondary aluminous chlorite, interstratified montmorillonite/illite, and interstratified montmorillonite/chlorite. Quartz in these samples can be found in traces. Of course, more detail mineral examinations are necessary in order to gain contents confirmation for the above-mentioned minerals (Frost *et al.* 2002).

ICP-OES. Dissolving the samples by fractionation, the resulting solutions were prepared for ICP-OES analysis to determine the concentrations of certain heavy metals in the SB basin soil.

Vanadium (V). In the Figure 5. values of the vanadium concentrations in samples are presented (ppm), and a histogram of this values comparative with maximum allowable concentration (MAC) values for this metal (Premović *et al.* 2001, Premović *et al.* 2002, Đorđević, 2009).

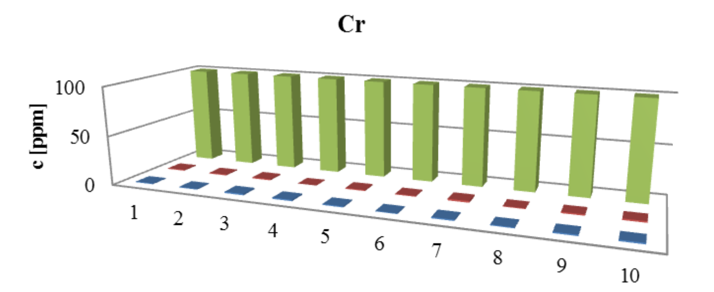
Taking into account MAC value, which is far above found concentrations, we could say that, as far as vanadium is concerned, the examined soil is safe for agriculture (Rehder, 1991).



	1	2	3	4	5	6	7	8	9	10
A	1,36	1,11	1,56	1,54	1,76	1,26	1,78	1,21	1,75	1,87
B	1,54	1,21	1,64	0,17	1,84	1,64	2,41	0,88	1,87	1,99
MAC	42	42	42	42	42	42	42	42	42	42

Figure 5. Vanadium concentrations in the examined samples and MAC

Chromium (Cr). Chromium concentrations in the samples are represented in the Figure 6. On this figure a histogram of this values in comparison to the MAC values (Kabata-Pendias *et al.* 2001) is presented for this metal.



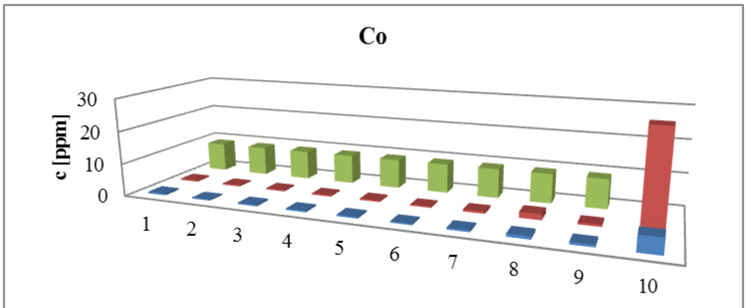
	1	2	3	4	5	6	7	8	9	10
A	0,69	0,62	1,31	1,26	0,96	0,56	1,22	0,86	1,19	1,27
B	0,84	0,86	1,21	0,09	0,98	0,77	1,65	0,64	1,32	1,43
MAC	100	100	100	100	100	100	100	100	100	100

Figure 6. Chromium concentrations in the examined samples and MAC

Based on the results represented in the Fig. 6 it can be concluded that soil from the tested area is, as far as the chromium is concerned, safe for agriculture.

Cobalt (Co). In the Figure 7. values of the cobalt concentration in the samples are presented, and histogram of this values and MAC value for cobalt.

In the sample with mark B-10 a value was measured where cobalt contents was above MAC value (Kabata-Pendias *et al.* 2001), and it can be concluded that the tested soil is not safe for agriculture as far as cobalt is concerned, and this requires cleaning measures.

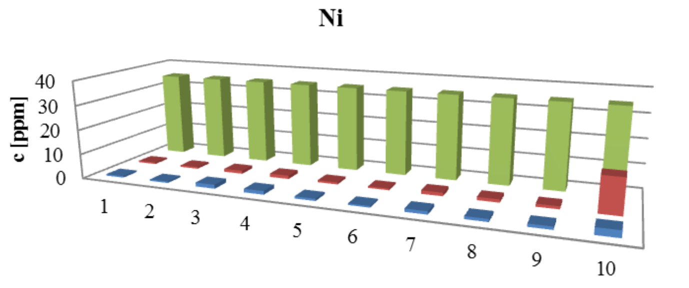


	1	2	3	4	5	6	7	8	9	10
A	0,52	0,34	0,46	0,47	0,49	0,39	0,56	0,86	0,71	4,64
B	0,48	0,39	0,45	0,42	0,49	0,37	0,65	1,76	0,61	28,78
MAC	9	9	9	9	9	9	9	9	9	9

Figure 7. Cobalt concentrations in the examined samples and MAC

Nickel (Ni). Values of the vanadium concentration (ppm) found in samples are presented in Figure 8 and a histogram of this values is presented comparative with MAC values for this metal.

As it can be seen from the Fig.8 found values of the nickel concentration are under MAC values (Kabata-Pendias *et al.* 2001), and it can be concluded that as far as nickel is concerned, examined soil is safe for agriculture.

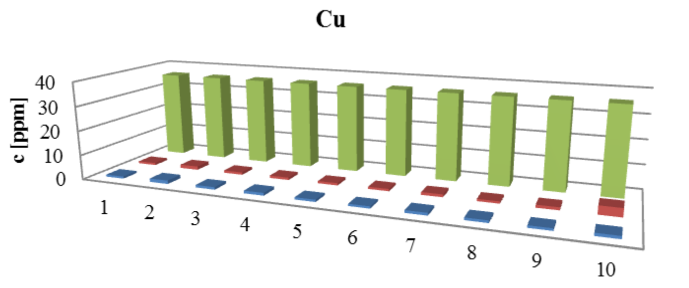


	1	2	3	4	5	6	7	8	9	10
A	0,62	0,61	1,61	1,43	0,88	0,63	1,25	1,13	1,19	2,71
B	0,65	0,74	1,27	1,38	0,84	0,69	1,41	1,23	1,15	14,23
MAC	35	35	35	35	35	35	35	35	35	35

Figure 8. Nickel concentrations in the examined samples and MAC

Copper (Cu). In the Figure 9. copper concentrations, found in samples, were presented, and a histogram of this values is presented as well as MAC for this metal (Kabata-Pendias *et al.* 2001).

From the presented results of the analysis, it can be concluded that, as far as copper concentration is concerned, the examined soil is safe for agriculture.

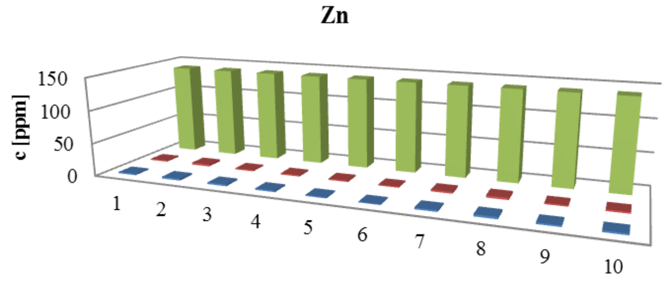


	1	2	3	4	5	6	7	8	9	10
A	0,86	1,42	1,03	1,09	0,89	0,86	1,03	0,97	0,91	1,12
B	0,88	1,41	0,98	0,99	0,93	0,92	1,12	0,88	1,15	3,45
MAC	36	36	36	36	36	36	36	36	36	36

Figure 9. Copper concentrations in the examined samples and MAC

Zinc (Zn). In the Fig. 10 zinc concentrations are given found in the samples. Histogram was presented of the found concentrations and compared with MAC values for zinc (Kabata-Pendias *et al.* 2001).

By examining zinc concentrations in the soil samples from SB basin values of the concentration, which is under MAC level for zinc, and it can be concluded that as far as the zinc concentration is concerned the soil is safe for agriculture.



	1	2	3	4	5	6	7	8	9	10
A	1,98	2,75	2,45	2,13	1,67	1,19	2,22	3,04	2,11	2,36
B	1,86	3,16	2,06	2,09	1,98	1,46	2,71	3,29	2,02	2,45
MAC	140	140	140	140	140	140	140	140	140	140

Figure 10. Zinc concentrations in the examined samples and MAC

4. Conclusion

The analysis results show that dissolubility of the tested samples goes from 19.1% to 31.8% for the samples from the soil surface, and from 17.8% to 30.4% for the samples from 30 cm depth.

FTIR analysis determines lower contents of the carbonate minerals in comparison to the silicate minerals, and that is confirmed with stereomicroscopy.

Based on the results gained from ICP analysis it can be concluded that soil from the tested area is safe for agriculture usage, except the soil from the area where sample with mark B-10 was taken and where Co concentration was found to be bigger than allowed for this metal. Measures of soil purification are recommended in this area in the aim of Co concentration reduction for the values above MAC.

References

Nesse W.D. Introduction to Mineralogy, Oxford University Press, New York 2000.

Goldschmidt V.M. The principles of distribution of chemical elements in minerals and rocks, Journal of the Chemical Society 1937;1937:655-673.

Pettijohn F.J. Sedimentary rocks, Harper Row, New York 1983.

Efe S.I. Spatial variation in acid and some heavy metal composition of rainwater harvesting in the oil-producing region of Nigeria, Natural Hazard 2010;55:307–319.

Kabata-Pendias A, Pendias H. Trace Metals in Soils and Plants, CRC Press, USA, 3nd edition, 2001.

Pierzynski G.M, Sims J.T, Vance G.F. Soils and Environmental Quality, CRC Press, London, UK, 2nd edition, 2000.

Alloway B.J. Heavy Metals in Soils, Environmental Pollution 2013:22;51-95.

Hu Y, Liu X, Bai J, Shih K, Zeng E, Cheng H. Assessing heavy metal pollution in the surface soils of a region that had undergone three decades of intense industrialization and urbanization, Environmental science and pollution research 2013;20:6150–6159.

Radivojević A. Geographical changes in Sokobanja ravine and their influence on the regional development, PhD defended on the Faculty of Geography, Belgrade 2008.

Premović P.I, Nikolić G.S, Premović M.P, Tonsa I.R. Fourier transform infrared and electron spin resonance examinations of kerogen from the Gunflint stromatolitic cherts (Middle Precambrian, Ontario, Canada) and related materials, Journal of the Serbian Chemical Society 2000;65:229-244.

Todorović M, Đorđević P, Antonijević V. Optičke metode instrumentalne analize, Hemijski fakultet, Beograd 1997.

Kerovec D. Određivanje koncentracije teških metala pomoću AAS-a i ICP-OES-a u uzorcima tla i biljke, Diplomski rad, Poljoprivredni fakultet, Osijek 2010.

Madejova J. FTIR techniques in clay mineral studies, Vibration spectroscopy 2003;31:1-10.

Frost R.S, Kloprogge J.T, Ding,Y. The Garfield and Uley nontronites-an infrared spectroscopic comparison, Spectrochimica Acta 2002;Part A:1881-1894.

Premović P.I, Nikolić N.D, Pavlović M.S, Todorović B.Ž, Đorđević D.M, Nikolić R.S, López L, LoMonaco S. The Cretaceous - Tertiary boundary Fiskeler at Stevns Klint, Denmark: geochemistry of major trace metals, Journal of the Serbian Chemical Society 2001;66:647-670.

Premović P.I, Đorđević D.M, Pavlović M.S. Vanadium of petroleum asphaltenes and source kerogens (La Luna formation, Venezuela): Isotopic study and origin, Fuel 2002;81:2009-2016.

Đorđević D.M. Termalna stabilnost vanadil porfirina u sedimentnim kerogenima, Doktorska disertacija, Prirodno-matematički fakultet, Niš 2009.

Rehder D. The bioinorganic chemistry of vanadium, Angewandte Chemie International Edition 1991;30:148-167.

Problems of landslides in Serbia, their prevention, remediation and insurance

Dragana Vušković[1], Danica Srećković-Batoćanin[2], Tatjana Đekić[1]

[1]*University of Niš – Faculty of Science, Višegradska 33, Niš, Serbia*
[2] *University of Belgrade-Faculty of Mining and Geology, Đušina 7, Belgrade, Serbia*

Abstract: Over the past ten years, particularly during the last two, the occurrences of natural hazards such as landslides, landfalls and rockfalls are frequent. Instability should be caused either by natural geological conditions (natural disaster) or by human activities, when is applied as technogenic or anthropogenic hazards. The main goals of this work are to highlight the causes of enhanced risk and necessity of their recovering and preventive measures, as well as the costs of estimated damages in accordance with the Law on Emergency Situations ("Official Gazette of the Republic of Serbia", no. 111/2009, 92/2011, 93/2012), Law on planning and construction (Official Gazette of the RoS, no.72/2009, 81/2009, 64/2010) and the Insurance Law (Official Gazette of the RoS, no.55/2004, 61/2005.85/2005.101/2007.63/2009).

Key words: natural disasters, landslides, flooding, preventive measures, recovery, refund of damages, insurance

1. Introduction

The area of Serbia, concerning the risk from natural hazards, is within the vulnerable regions. Approximately 30% of its territory is exposed to landslides. The number of landslides in Belgrade exceeds 750 and in Serbia as many as 36000. The more vulnerable areas in Belgrade are Karaburma, Mirijevo and some parts of Zvezdara. Large and complex landslides are those near Beška, Čortanovci, landslide Duboko at Umka, the area between Belgrade and Smederevo, road along the Djerdap Gorge, etc.

However, landslides are the global problem. The annual costs for damages caused by worldwide landslides are estimated on several billions of dollars. These disasters give thousands of human victims every year. Introducing with these emergencies and avoiding construction on land at risk is necessary for reducing damages (http://www.geologija.org/articles/geo.php?t, 2006).

The large flood events in 2014 led to landslides that caused great loss to inhabitants and economy in Serbia though the possibilities and ways of compensation of these damages need to be taken in consideration.

2. Methods and results of researches

In this paper were applied normative-analytical and statistical methodology based on analyses of valid rules that concern natural hazards and emergency situations, the conditions and modalities of construction and insure properties, as well as statistic data obtained by the insurance companies Axa and Delta Generali.

Obtained results led to conclusion that is Serbia seriously endangers by landslides and that measure for elimination of causes and harmful consequences has to be undertaken.

3. Landslides

3.1. The development of landslide

Landslide occurs on terrains built of young and weakly cemented rocks, especially on Tertiary and Quaternary clays, but may occur at flysch products composed of marlstone, sandstone and limestone. The development of landslide depends on geological background and being additionally supported by tectonic movements, which took part during the geological evolution (Čolić, 1987)

Landslides occur on slopes of various angles, from very gentle to steep. The speed of movement of material widely ranges, and the final effects of land sliding depend on the volume and speed of downslope movement.

Landslides are often the consequence of some misbalance (instability) of soil. They represent an “attempt" of soil to reach the balance (stable) state. They become active usually after torrential rain flows or sudden melting of snow. Two elements are required for the development of landslide:

1. Slope
2. Water

Water erosion takes part with any rain drops that falls on the ground. The intensity of erosion depends from speed and intensity of rainfalls. The latter varies from very mild to torrential. The erosion is commonly caused by more intensive rainfalls, with the intensity of about 1 millimeter per minute (Gavrilović, 1987)

However, the existence of slope saturated with water does not lead always to formation of landslide. Numerous factors, such as type of soil, steepness of slope, level of ground water, rate of soil damage caused by tectonic movements or by human activities, earthquakes, volcanoes, weight of artificial objects on slope (roads, buildings, etc.) control landslide formation. In the sense of lithology (type of soil) the clays are particularly significant in landslide generation. Clays are able to absorb water and swell (increasing their volume up to 3-4 times). Although the landslide may occur at gentle slopes, the risk of it increases with the steepness of a slope. As a rule, landslide forms with the rise of level of ground water. Tectonic is also the important factor. If the sedimentary layers deep parallel to the slope, than bedding planes easily can be transformed into sliding surfaces. Tectonic movements can disturb ground causing misbalance that develop landslide afterwards. Instability of ground is often caused by human activity. Construction of building at inappropriate locations can overlade the slope and initiate the landslide development. Additionally, the constructions of certain objects at unsuitable places can embarrassment ground water and accumulation of large amount of water at the slope base. Digging and storing of large amounts of soil at certain places lead also to misbalance of the slope and to landslide development. Earthquakes disturb the stability of slopes and support the occurrence of sliding. Those with magnitude exceeding four are called "initiators of landslides" (Petković, 1978).

3.2. Types of landslides

Landslides may be classified using different criterions: structure of slope, place of origin, way of motion, depth of sliding surface etc. (Marković *et al.*, 2003).

According to the depth of sliding surface can be distinguished:

1. **Surface** (up to 1m deep),
2. **Shallow** (to 5m),
3. **Deep** (to 20m) and
4. **Very deep landslides** (exceeding 20m).

According to the mode of origin could be recognized:

1. **Delapsive landslides** (landslide impulse spreads from the basis of slope upward, towards the top),

2. **Detrusivne landslides** (forms at higher altitudes on slope and shear forces spread downward, towards the basis)

According to the shape of sliding surface, relief and way of motions Bognar (1996) distinguished:

1. **Creep,**
2. **Rotational,**
3. **Stepped landslide,**
4. **Block landslide,** and
5. **Earthflows landslide.**

Heavy rains in our country in May, 2014 and afterwards left a large amounts of water that eroded and destroyed ground, moving a part a huge amounts of eroded material. Torrential streams destroyed fields, roads, railways, houses and other objects. After floods, a broad landslides occurred (Figures 1.2.3, and 4).

Figures 1 and 2. Landslides in the village Bogdanje by Trstenik. (http://www.geologija.org/articles/geo.php?t)

Figures 3 and 4. Landslides (http://www.rtv.rs/sr_lat/drustvo/spiskovi-klizista-za-sanaciju_487209.htm)

3.3. Rehabilitation of unstable occurrences

Restoration of unstable terrain itself includes the determination of the terrain's property within the broader area, as well as in the area of landslide. This process embraces various geological methods (engineering-geological, land mechanics, hydrogeological, etc.). According to obtained data the decision of restoration or utilization of certain measures (reforestation, arrange of park surfaces etc.) takes place.

Large landslides lead to catastrophes. The restoration of unstable regions, particularly landslides, is one of the heaviest geotechnical tasks. Struggle against is very hard, long-lasting and expensive in spite being often unreliable (Čolić, 1987).

The main prevention measure is the elimination of the cause of landslide development. As the water represents one of the main factors, the gathering of water in susceptible terrains requires a particular attention. In urban areas the construction of appropriate sewage system is obligatory. Septic tanks and damaged sewer systems destabilize terrain. Vegetation of high absorption ability for sufficient moisture (e.g., willow) should be plant where it is possible.

Forests help in stabilizing ground by tree roots. However, vegetation does not help significantly at broad landslides as a sliding surface is often at depths greater than that of roots. In such cases the whole forest removes. Landslide in forest is accompanied with bending of trees and such occurrence is referred “crooked forest”.

In some cases at already removed landslides is not possible to apply rehabilitation until they stop moving. Such case is in the village Bogdanje, near Trstenik, where nearly all inhabitants had to be displaced due to landslide approximately 2 km long (http://www.geologija.org/articles/geo.php?t).

The struggle against landslides commonly includes diggings up, use of piles, building of defense walls and accesses a drainage (carrying off water). Identified rockfalls and landslides in Serbia are presented at the map, which was prepared by the Institute for roads in Belgrade (figure 5).

4. Remediation of damages after natural hazards

4.1. The loss of damages caused by natural hazards in Serbia, excluding the earthquake in Kraljevo, until December, 2013 reached 10.5 billion of dinars. This estimation was presented in the journal „All about insurance“ by the Government Commission for Emergency Situations on the basis of data proceeded by local self-governments. It has been estimated that the renovation of houses, hospital, schools and other destroyed objects in Kraljevo would cost at least the same. According to the preliminary estimation for floods caused by the River Lim, the additional half of one billion of dinars will be needed. Therefore, the total sum of loss is 21.5 billion of dinars, and the biggest part will be provided over taxpayers (http://www.sveoosiguranju.rs/?page=227).

The announce of emergency situations, when a sudden disaster interrupts a common life, brought victims and either a great damages of properties or its loss including damages in infrastructure that exceed the financial ability of an community. In such instances endangers are left only to compassion and the potential budget excess. The latter is commonly missing. For example, the budget for 2013 predicted six time lesser amount for covering costs of injures or damages caused by elementary disasters or some other natural hazards than it has been really after floods, discharge of ground water, hails and landslides.

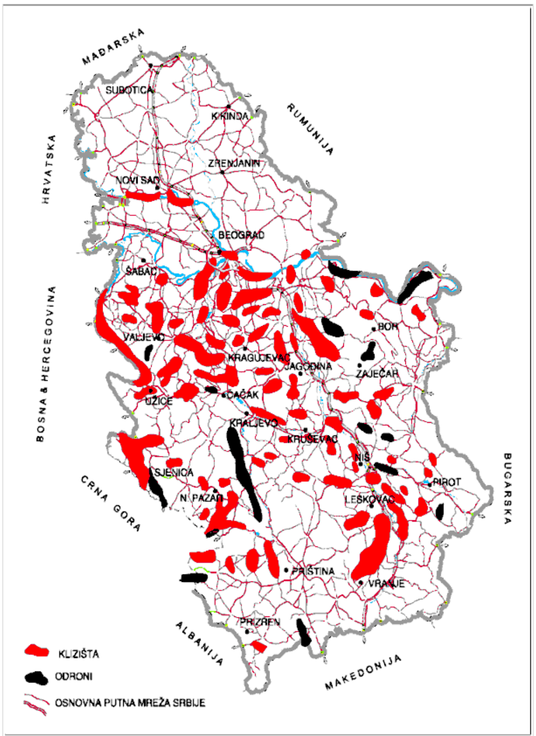


Figure 5. Map of rockfalls and landslides in Serbia (Abolmasov, 2014)

4.2. The whole year is behind the catastrophic flood events, the largest emergency situation in Serbian history. Total costs and financial loss exceeded 1.53 billion of euros, what is 4.5 % of the gross national income in Serbia. The costs for recovery and remediation are mostly paid by national budget resources, donations and foreign credits, whereas the insurance companies covered insignificant part of the total loss (http://bif.rs/2015/07/osiguranje-u-borbi-protiv-elementarnih-nepogoda-kad-ce-to-meni-da-se-dogodi/).

4.3. Economy and inhabitants were not assured and such trend excluding the short-lived interest for the insurance just after terrible floods, continued. The citizens did not change their decision concerning insurance although a catastrophic scenes of flooded, almost sunk cities and destroyed houses, and drowned cars including efforts and advices of economic advisers to protect their properties and assure them for emergency situations.

Undoubtedly the conscience of insurance regarding natural hazards should be much higher in the country that has been hit within the last decade several times with destroyable tempests and human victims and significant material losses (earthquakes in Mionica, Kraljeva, floods along the watersheds of the Rivers Danube, Sava and Tamiš, and subsequently landslides).

In spite worst economic situation and low conscience on the insurance significance, the Republic of Serbia has in the future decade to yield and apply measures for increasing the role of insurance companies in solvation of problems after elementary disasters. Thereby, the insurance would be much more important resource for recovery programs than it is now.

4.4. The first step should be the establishing the Strategy of Serbia, which should clearly determine the obligate insurance and those state needed. So, the priorities would be defined. As been exposed to inappropriate influence of climate changes and frequent accidents, Serbia needs to protect its strategic segments. The last year, when disaster flood events in May destroyed expensive equipment of state companies which were not assured, should not be repeated ever again (http://bif.rs/2015/07/osiguranje-u-borbi-protiv-elementarnih-nepogoda-kad-ce-to-meni-da-se-dogodi/**)**

One of the main measures should be to insure the large state corporations from natural hazards. The most endangered sectors by mentioned floods were mining and energy sector. Although their loss was estimated on 180 million of euros, it is much more due to break in coal production. The state was forced to export electricity to supply the economy as well as citizens.

Though the total loss exceeded 300 million of euros, reflecting that the mining and energy sector experienced a deficit of nearly half billion of euros.

Another step should be the implementation of insurance from natural hazards for collaterals. Any credit given by a bank and supported by hypothecation of properties should include insurance from natural hazards not only from a fire as at present.

4.5. Insurance companies suggest to introduce the so-called „French model" of insurance against loss from natural hazards, which although simple and of acceptable price, allows citizens better financial support in extreme weather instances. This model considers the legislations between insurance policies for fire rescue with risks from floods, earthquakes, hails etc. This will enable to owners of policies for house or apartment protection against the main risk to count on covered risks from the natural hazards, too. This model is also applicable on the economy.

The example of Romania, which introduced the obligatory insurance after the flood events in 2010, although less destructive than that in Serbia, is often mentioning as a proposal in our country.

4.6. Serbian citizens hardly insure their property. According to data of the Central bank, the total rate of premium from insurance from floods and earthquakes makes only 0.8 % of the total rate of premium from general (any that is not life insurance) insurance. According to data provided by the National bank of Serbia for the past nine month the insurance from floods participate with only 1.5 % of the total rate of premium from general insurance; against risk from earthquake about 0.6 %. It should be emphasized that statistical approaches were not practiced until this year.

There are two reasons for such suspicion of Serbian citizens. Although a majority of the insurance companies do not ask license application or legalization document for object, if their workers get opinion that house or office is on rescue land and may be easily drowned every year, the premiums may be very high and out of financial ability. If this insurance is obligatory, than the premium would be lower, due to greater number of houses/objects that are covered with insurance.

The second reason has psychological roots. Actually, citizens do not have in their mind that elementary accidents occur worldwide, i.e. everywhere and that nobody is "spared". However, the interest of citizens for policy insurance that encloses risk from earthquake increased, although not drastically, after the earthquake in Kraljevo.

4.7. Taking into consideration that the elementary accidents became serious threat, the insurance companies underline this type of insurance. In this situations when people do not insure their properties even from the major risks, and expect help from governments if something bad happened, the country is that who is responsible and should involve significant changes and enlarge number of obligatory insurance.

5. Conclusion

According to all cited above, may be concluded that the area of Serbia is seriously exposed to risks from landslide and that in the last two years these occur at large scale. Landslides derived after floods in 2014 caused the enormous loss to citizens and economy. Efforts for the loss reduce include better knowledge and introducing with these occurrences. The elimination of causes needs sustainable strategy of prevention measures and recovery. Their implementation for already undergone damages exceeds the financial capability of the country itself. One of the possibilities in providing financial support and financial safety in emergency situations is that country has to accept measures for increasing role of insurance in such cases. This should be provided either over the obligatory act within the already existed standards defined by low or by introduce the quite new regulative.

References

Albomasov B. 2014. Predavanja iz inženjerske geodinamike. Zaštićena multimedijalna prezentacija. www.rgf.rs

Gavrilović Z. 1987. Elementarne nepogode i katastrofe: Prvo jugoslovensko savetovanje u Budvi. Narodna tehnika, SSNO, Beograd, 297-311

Marković M., Pavlović R., Čupković T. 2003. Geomorfologija, Rudarsko-geološki fakultet. Zavod za udzbenike, Beograd.

Petković K. 1978. Geologija Srbije. Inženjerska geologija-VIII-2. Zavod za regionalnu geologiju i paleontologiju, Beograd.

Čolić B. 1987. Elementarne nepogode i katastrofe: Prvo jugoslovensko savetovanje u Budvi. Narodna tehnika, SSNO, Beograd, 282-296

http://www.geologija.org/articles/geo.php?t (2006)

http://www.rtv.rs/sr_lat/drustvo/spiskovi-klizista-za-sanaciju_487209.htm (2014)

http://www.sveoosiguranju.rs/?page=227

http://bif.rs/2015/07/osiguranje-u-borbi-protiv-elementarnih-nepogoda-kad-ce-to-meni-da-se-dogodi/

Geographic transformation of the Ibarski Kolašin in the XX century

Ivanović Radomir[1], Ivanović Marko[2], Radovanović Dragan[1], Penjišević Ivana[1]

[1]*Faculty of Sciences and Mathematics, University of Pristina with temporary Head Office in Kosovska Mitrovica*
[2]*PhD student, Faculty of Geography, University of Belgrade*

Abstract: Development of human activities and social needs inevitably imply a transformation of the geographic environment as well. Exploitation of minerals or some other natural resources may lead to sudden and very damaging distortion of the natural environment - formation of overburdens, dumpsites and the like. Rare are the cases when, seemingly, a common human activity brings a true revival of an area.

The Ibarski or Stari (Old) Kolašin is a micro-region in the northwestern part of Kosovo and Metohija, in the middle part of the Ibar River course. In the past, this area had been unjustly neglected. For many reasons, the Ibarski Kolašin has been at the periphery and in complete isolation for decades. The population lived very hard of agriculture, but only for their own needs with a very small surplus of products, which was being brought with great difficulty, due to bad roads, to the markets of the closest cities - Kosovska Mitrovica and Novi Pazar. Anonymity and isolation lasted until the construction of the land part of the Adriatic Highway (route E65). Construction of the modern road, in 1968, has contributed to the Ibarski Kolašin to become a very important transit area. Another important event, which has brought negative, but also positive consequences, was the construction of the "Gazivode" reservoir within a huge hydrosystem "Ibar-Lepenac". The reservoir has remarkably fitted into the environment, thus creating the perfect predisposition for the overall economic development, but particularly the development of tourism and related activities.

Keywords: Isolation, geographic transformation, resources, the Ibarski Kolašin

1. Introduction

The Ibarski Kolašin has had a very turbulent past due to its important geographical and geopolitical location. The region was marauded by numerous armies and looters. Prominent people were exiled, murdered and pillaged and the villages were burned down. On many occasions, the residents of the Ibarski Kolašin stayed without their possessions. Very bad routes did not connect this region to the world, so it was condemned to isolation. This isolation from the other parts of Serbia took a very long time which resulted in the exodus of the population, mostly young people. Depopulation threatened the Ibarski Kolašin. Isolation continued for the next twenty years after the World War II. While all other main parts of Serbia were rapidly developing, the Ibarski Kolašin remained in the background.

In 1968, the Ibarski Kolašin finally gets a modern road and it is the first construction built by the state in this area. This led the Ibarski Kolašin out of the centuries of isolation and enabled better employment opportunities and better traffic connection. Another event influenced not only the geographical, but also overall transformation of the Ibarski Kolašin. Construction of the "Gazivode" reservoir completely changed the appearance of the area. Much disputed, it nevertheless provides remarkable opportunities for the economic, and above all, tourism development.

2. Geographical location, borders and size of the Ibarski Kolašin

The Ibarski or also called Stari (Old) Kolašin is a mountainous micro-region in the northwestern part of Kosovo and Metohija. More specifically, it includes the valley of the middle course of the Ibar River, from the Ribarićka gorge in the west to the village of Zupča near Kosovska Mitrovica in the east, as well as the parts of the mountains Rogozna in the north and Mokra Gora in the south. The exact borders of the Ibarski Kolašin are difficult to determine because they often changed in the course of history. According to popular opinion, the Kolašin begins from the Ribarićka gorge and ends with the last Serbian houses in the village of Zupča, including also all Serbian villages between Rogozna and Mokra Gora (Stojanović, 2009). More precisely, the border in the west is the river gorge of the Crna reka to Ribarić, it comes down by the course of the Ibar River to the Crnovrška reka, goes by the watershed of the Ibar River and Raška on Rogozna (northern border), then by the valley of the Jagnjenička reka to the village of Zupča on the Ibar River. The border then goes by the Zupčanski potok (stream), enters the basin of the Beli Drim (upper course of the Klina River) to the stream of Dubočak (eastern border), and then by the ridge of Suva and Mokra Gora to the Crna reka (southern border) (Ivanović, 1991). However, in a broader sense, the Ibarski Kolašin also includes the villages directly by this border: Mojstir, Crna Rijeka, Zlatare, Žarevo, Ribarić and several villages in its surrounding area, Donji Strmac in the valley of the Klina River and the village of Čabra in the valley of the Ibar River (Stojanović, 2009). In administrative terms, the territory of the Ibarski Kolašin is mostly located in the Municipality of Zubin Potok, and a significantly smaller number of villages belong to the municipalities of Tutin, Novi Pazar, Zvečan, Istok and Srbica.

The territory of the Ibarski Kolašin is of an irregular shape: the length of about 30 km, the width of about 16 km, which makes it an area of approximately 335 km^2. It has 63 villages and the administrative centre of Zubin Potok.

In geopolitical terms, the territory of the Ibarski Kolašin has always been considered very important. All important events of the Serbian history have taken place on this territory. Population of the Ibarski Kolašin is Orthodox, Serbian, and placed between the Islamic population in the west and in the north (the region of Raška - Sandžak and Gornje Polimlje), mostly the Albanian population in Metohija and Drenica in the south and the mixed population in Kosovska Mitrovica in the east. Thus, it is a solid and great oasis of the Serbian population surrounded by the Islamic population.

3. The Ibarski Kolašin in the period before the World War II

In the early 20th century, life in the Ibarski Kolašin was very difficult. Numerous incursions of the Arbanasi in the Ibarski Kolašin villages were everyday occurrences. Murders, rapes, lootings and burning of villages had only one goal – the persecution of Serbs from these regions. Population of the Ibarski Kolašin was forced to arm up and in that way protect bare life and property. In order to achieve this goal easier, the prominent Serbs were expatriated (Archpriest Vukajlo Božović). This situation lasted until the liberation in 1912. After the liberation from the Turks, six municipalities were formed - Brnjak, Lučka reka, Rujiš, Radič polje, Ribarić and Crepulja. Besides Ribarić, which belonged to the county of Štavik in the district of Raška, other municipalities belonged to the county of Mitrovica in the district of Zvečan. According to the census, 7,496 inhabitants lived in this area in 1914 (Virijević, 2012).

The main economic activity in the period before the World War II, was the extensive agriculture: crop and fruit growing in the valley and hilly areas and cattle breeding in the mountains. Production of agricultural products was mainly for the own needs, while very little remained for the market. Dairy products, leather, wool and livestock were mostly traded, and Rogozna was recognizable by its potatoes. There was quite a little wheat and corn was mainly cultivated. Of cattle, mostly goats were bred on Rogozna and sheep on Mokra Gora. Also, workhorses were bred, but only in well-off households which used them in hired labour to transfer various goods to the market. In this region, several larger hired labour holders were known. Radovan Milosavljević from Kozarevo, a wealthy householder, held up to 20 horses. He transported tobacco, salt, sugar and other goods from Skoplje to Pljevlja and a Kolašin Duke, Nedeljko Nešo Božović from Pridvorice, used to go even to Thessaloniki, Shkodra, Dubrovnik and Sarajevo with his caravans (Luković, 2009).

The Ibarski Kolašin also nurtured crafts, the so-called household industry. The Ibarski Kolašin is abundant in quality forest, so the carpenter's and barrel manufacture crafts developed. It was specially developed and known in the villages on Mokra Gora. The products were sold mainly in Metohija. The village of Bube was known by its potters and Crepulja by its scales manufacturers. Plenty of streams and small rivers that flow into the Ibar River from Rogozna and Mokra Gora caused the work of many water mills and roller mills. There were more than 20 mills and roller mills only on the Čečevska reka (Lutovac, 1954). The roller manufacturers of the Ibarski Kolašin used the cloth for processing what was brought in from more distant areas - Metohija, Tutin, Drenica and the region of Novi Pazar.

The main problem with placing goods on the markets of the surrounding cities represented bad roads. The main means of transport were horse-drawn carts and more often horse-drawn caravans. The main road went along the Ibar River and it was written that the road was in very poor condition, and according to some writings, it was built yet in 1873. Before that, there were no roads (Luković M., 2009). From this road, several transversal roads separated over the saddle of Rogozna and Mokra Gora. The roads on Rogozna mainly led towards the most famous and oldest transport route of the region. By the eastern periphery of the Ibarski Kolašin goes the famous Bosnian Road or "stara džada" as called in the Ibarski Kolašin. This is the road that leads from Sarajevo, via Pešter, Novi Pazar, Rogozna to Kosovska Mitrovica and continues to Priština and Skoplje to Thessaloniki. What was the condition of this so important transport route, described Jovan Cvijić: "among the traffic connections of the greater importance on the Balkan Peninsula, this is one of the most difficult and worst ..... this is a bad road; the road sides are only covered by soil in such order to let the chariots pass besides the ravines and chasms; the brooks have no bridges, people must walk over them. This is mainly a caravan route" (Cvijić, 1996).

Along these roads, another economic activity has developed. The inns were built with the aim to allow travelers and traders with their caravans to spend the night and rest and also gave food for the horses. The inns were usually built in places where the roads intersected or where the bridges across the Ibar River were placed. There were six inns only in the village of Pridvorica. Most of them were by the longitudinal road from Mitrovica to Ribarić, but there were inns at cross roads, especially on the "stara džada" and the roads leading towards it.

Another occupation was also interesting. The villagers of the upstream villages: Mojstir, Jezgrović, Gazivoda and others, earned additional income by rafting down the Ibar River. Logs from the forests of Mojstir were sliding down the Ibar River to Mitrovica and Zvečan. Later, instead of individual logs, the rafts were built that skilled rafters tracked to Mitrovica. It is registered that, at the medium and high water levels, a distance from Ribarić to Mitrovica can be passed over in the daytime and at low water level, one can barely reach the Radič polje (Virijević, 2012).

In 1921, in Kosovska Mitrovica, the sawmill of the Draga family began to work using logs that were transported by the Ibar River. The sawmill operated successfully until 1928. In Kosovska Mitrovica, another sawmill owned by an industrialist Lazar Žarković began to work in 1930, and after a series of difficulties in the business, a joint stock company "Ibar" was established. Of course, the raw material base represented the forests of Ibarski Kolašin (Group of authors, 1979).

In 1930, Lazar Žarković built the hydropower plant of 432 KW in the village of Čečevo, at the Čečevska reka, for the needs of Kosovska Mitrovica. It was the only industrial facility in the Ibarski Kolašin before the World War II. The hydropower plant was very important for this region because it employed a dozen of workers from the immediate surrounding areas. That is why the locals lovingly called it "centrala (headquarters)".

A significant contribution to economic conditions of the Ibarski Kolašin is the start of the first operational plants of "Trepča" in Kosovska Mitrovica. However, the limiting factor for prosperity was, as always, a bad connection to the surrounding areas and the closest center - Kosovska Mitrovica.

4. The Ibarski Kolašin in the period after the World War II

The World War II brought new sufferings to this region. The territory of the Ibarski Kolašin was divided into two zones of occupation - German in the north and Italian in the south. The border was the Ibar River. The Italian part of the Kolašin was very quickly added to the so-called "Great Albania" which was the signal for the start of a new pogrom of the Serbian population. During the occupation, 256 Serbs were killed, 2,907 were tortured in a various manner, 1,730 buildings were burnt down and over 87,000 pieces of cattle were looted (Rastović, 2012).

In the postwar period, isolation of the Ibarski Kolašin continued. Young people began to emigrate from the Ibarski Kolašin massively, usually to Kosovska Mitrovica, but also further to Kraljevo, Kragujevac and Smederevo. The Ibarski Kolašin did not only have any new investments, but the existing plants were shut down as well – the hydropower plant and the sawmill in Čečevo. Kosovo and Metohija had a reputation of underdeveloped territory and all the republics of the former Yugoslavia allocated huge funds for economic development, but the funds did not come to the Ibarski Kolašin. The Municipality was also abolished and the territory of the Ibarski Kolašin was added to the Municipality of Kosovska Mitrovica in 1965. Kosovska Mitrovica, Novi Pazar and Metohija were still difficult and slow to reach and people travelled by poor gravel roads, muddy or dusty depending on the season. The basic means of transportation were still carts and pack horses, with very few field automobiles. Without any of the economic facilities, poor agricultural production, aggravated promotion of agricultural products and firewood, the Ibarski Kolašin was sentenced to slowly disappearance. More and more young people were leaving, so this area slowly almost stayed without the population. This situation has also continued for several decades after the World War II.

At the end of the 1960-ies (1968), the land part of the highway, i.e. route E65, passes through this territory connecting Kosovska Mitrovica, that is, the Ibar Highway, through Rozaje and Berane with Podgorica and the Adriatic Sea. This highroad was the first investment in infrastructure or some other facility in the Ibarski Kolašin in socialist Yugoslavia. This led to the opening of the Kolašin to the world, exit from decades of isolation. This highway was the shortest connection of eastern and southern Serbia, Kosovo and Macedonia to the Adriatic Sea. Columns of tourists passed through the Ibarski Kolašin. So this region has become a very important transit area, which has always been. Not only that this modern highroad has allowed a much faster transfer of goods and passengers, but has also influenced the revival of catering industry in this region. Instead of the former inns, restaurants and motels "emerged". Motels with bungalows were opened in Zupča and Zubin Potok, and only a motel in Ribarić. In order to connect remote villages with the highway, several bridges over the Ibar River were built. The very construction of this highway has employed a large number of workers from this territory. So, the Ibarski Kolašin has been saved from extinction and its natural wealth and beauty are becoming available and suitable for exploitation.

Another capital investment has greatly changed the Ibarski Kolašin in geographical, as well as in every other sense. In 1977 the construction of a dam on the Ibar River near the village of Gazivode was completed and filling of the eponymous reservoir began. Many people in the Ibarski Kolašin felt that the dam is detrimental and that it was another attack on this region. Something similar happened. In a cruel manner, quickly and often with a symbolic compensation, partially or completely, a dozen villages of the Ibarski Kolašin were flooded (Kovače, Gazivode, Rezala, Tušiće, Banje, Špilje and other). Population of these villages partially remained in the Ibarski Kolašin, but a large number of people moved to central Serbia.

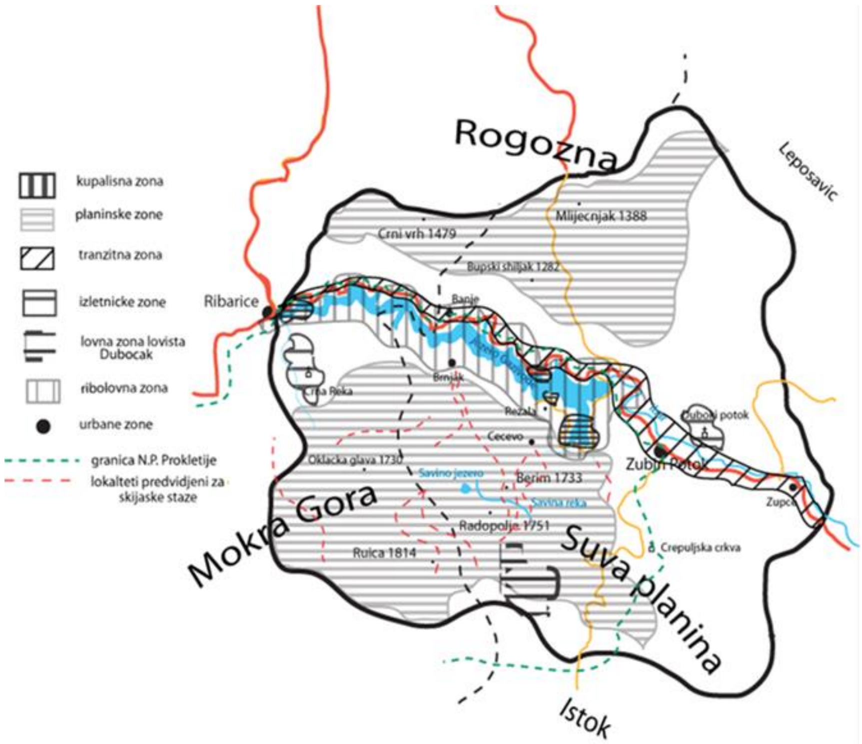
The built hydropower plant, reservoir and compensation basin, the so-called “Malo jezero” (Small lake) and canals that drain water to the valley of Kosovo, are an integral part of the enterprise "Ibar-Lepenac" based in Priština. The reservoir was built, among other things, to supply water to Kosovska Mitrovica and a number of settlements in its surroundings, but not for Zubin Potok that even today, in the summer period, has a serious deficit of drinking water. By filling the reservoir, the villages of Mokra Gora were practically cut off from the world.

On the other hand, the reservoir has remarkably fitted between two mountains which provide excellent opportunities for the development of tourism and related activities (Ivanović et al., 2011).

By persistence of prominent people and change in policy of the Republic of Serbia, the Ibarski Kolašin was returned its municipal administration in 1987. A period of general rebirth and renewal has begun.

During the 1990-ies, several industrial plants were built in the villages Čečevo, Ugljare, Gazivode, Brnjak, Donji Jasenovik and in Zubin Potok. A fish pond was opened in Gazivode managed by agricultural cooperative "Zubin Potok". Unfortunately, the economic crisis in the whole country has affected these companies as well and many have been closed or drastically reduced the number of employees. A magnificent infrastructure project was also built - a bridge across the lake in the village of Brnjak which connected the villages of Mokra Gora to the highway. Today it is one of the symbols of the Ibarski Kolašin.

In recent years, much has been invested in tourism, and in that purpose, several small hotels and motels were built - motel "Zapis" with 16 beds, motel "Aleksandrija" with 10 beds, a city hotel in Zubin Potok with 12 beds, motel "Villa Jakšić" with 18 beds, the youth camp in Rezala on the lake shore, and there are plans for building an ethno village in Špilje. By all estimates, the Ibarski Kolašin has the potential for the development of mountain tourism (Mokra Gora), excursions, transit, hunting (Mokra Gora and Rogozna), fishing and nautical (reservoir Gazivode) and rural eco-tourism (Ivanović et all., 2011).



Picture 1. Zones of tourism development of the Ibarski Kolašin region (Ivanović at all.2011)

5. Conclusion

Neglected in every respect, the Ibarski Kolašin was isolated from the surrounding world. With poor and primitive agriculture, very bad roads, no opportunities for employment, the population has been living very difficult. Even in recent history – in socialist Yugoslavia, this region lived as in the Middle Ages. And when the huge funds were paid to the underdeveloped province of Kosovo and Metohija, and other parts of Serbia rapidly developed, this region remained aloof and in isolation. The Ibarski Kolašin was simply "sentenced to extinction" by the provincial government. The inertness of Belgrade has contributed to that. The population has been rapidly decreasing. Especially young people have been leaving in search of employment. Their objective were big industrial centres - Kosovska Mitrovica, Kraljevo, Kragujevac, Smederevo and others.

The year of 1968 was significant, because in that year the Ibarski Kolašin came out of isolation. The modern highway - land part of the Adriatic Highway was built (route E65). This was the first investment in any facility in the Ibarski Kolašin in socialist Yugoslavia. Along the route of the highway throughout the Ibarski Kolašin, restaurants, hotels and motels open and it gives new strength to this nation to survive. Catering industry and trade have begun to develop and the highway has greatly facilitated the overall life to the people. The beauty and natural resources of the Ibarski Kolašin have become available to many tourists passing through. From a totally isolated, this region has grown into an important transit area.

The Ibarski Kolašin is experiencing a huge geographic transformation by the formation of artificial reservoirs of "Gazivode" within the hydropower plant "Ibar-Lepenac". Much disputed among residents of the Ibarski Kolašin, the reservoir has remarkably fitted between two mountains, which offers tremendous opportunities for the development of various forms of tourism and related activities. The sites like the lake in the length of 22 km, its clear water, preserved nature of Mokra Gora and Rogozna, favourable terrains for winter sports, rich flora and fauna and especially the hospitality of the people and their love of the Ibarski Kolašin, enable the development of transit, mountain, nautical, fishing, hunting, excursion and rural tourism and other economic sectors that accompany tourism.

Unfortunately, since 1999, this territory, as well as the entire territory of Kosovo and Metohija, has been under the administration of the international community which represents a limiting factor in the overall development of the economy and the unilateral declaration of the so-called "Republic of Kosovo" further brings anxiety among the local population due to bitter experiences in the past.

References

Cvijić J. Fundamentals of Geography and Geology of Macedonia and Old Serbia. Collected Works of Jovan Cvijić, 1996 12.

Group of authors. Kosovska Mitrovica and its Environment. Municipality of Kosovska Mitrovica.1979.

Ivanović R. Hydrographic characteristics of the Ibarski Kolašin. Geographical research 1991; 12: 67-75.

Ivanović R., Šaćirović S., Ivanović M. Spatial Plan for Tourism Development of the Ibarski Kolašin, Novi Pazar Collection of Papers 2011; 34: 173-185.

Ivanović R., Ivanović M., Đokić M. Hidrographic potentials of the Ibarski Kolasinin funkcion tourism development. Glasnik SGD 2011; 91(1): 117-134.

Luković M. Traffic and economic connections of the Ibarski Kolašin. The Ibarski Kolašin - nature and traditional culture 2009; 79-117.

Lutovac M.The Ibarski Kolašin - anthropogeographical researches. Serbian Ethnographic Anthology, Settlements and Origin of Population 1954; 34.

Rastović A. The political situation in the Ibarski Kolašin from 1878 to 2000. The Stari (Old) Kolašin - Thematic Collection of Papers 2012; 117-141.

Stojanović M. Nature of the Ibarski Kolašin. The Ibarski Kolašin - nature and traditional culture, 2009; 15-78.

Virijević V. The Ibarski Kolašin from 1912 to 1941. The Stari (Old) Kolašin - Thematic Collection of Papers, 2012; 101-117.

Drought and its impact on the yields of field crops in the area of Nišava district

Jelena Živković[1], Marija M. Dimić[1]

[1]University of Niš, Faculty of Science and Mathematics, Department of Geography, Višegradska 33, 18000 Niš, Serbia

Abstract: Drought is a sub-type of climate related natural disasters. Unlike many natural disasters, drought is not a sudden phenomenon. It develops slowly, rarely causes rapid and dynamic losses in human lives. However, because of the appearance of hunger caused by it, as well as because of its direct effects, the consequences are sometimes very serious. The greater part of the territory of Nišava District (Dobrič, the valleys of Niš and Aleksinac) belongs to the areas most affected by drought in Serbia. This paper will analyze the impact of drought on yields of prevailing field crops in Nišava District, in the period 2006-2013.

Key words: drought, yields, field crops, Nišava district

1. Introduction

Along with the technological progress of mankind, which is manifested by an increase in the level of environmental degradation, the quantity and frequency of natural disasters also increases. In the first decades of 20th century, only a few dozen of natural disasters were registered in one year, although there are no records for some years. In the last two decades of the 20th century, the number of natural disasters has increased to over 200 per year. Only in 2010, EM-DAT, registered 373 natural disasters (Lukić et al, 2013). The increase in the frequency of natural disasters can be linked to future climate scenario. According to it, by 2100, the expected increase in air temperature is in the range of 1.1 and 6.4^{o}C on a global scale. And the expected increase of the sea level is between 18 and 59cm (Komac et al, 2013).

There are many differences in the definition and classification of natural disasters. It is difficult to provide generally accepted definition of what natural disasters really are, except when they are clearly identified. Definitions of natural disasters generally tend to cover all physical causes of their appearance. However, they are not always the result of the action of natural processes on the environment only, but often the result of the interaction process between the natural and anthropogenic systems (Lukic et al, 2013).

According to CRED (Center for Research on the Epidemiology of Disasters), natural disaster is any sudden and unpredictable situation or event that causes great destruction, property damage and human suffering, in situations where there are problems caused by it, beyond the capabilities of local communities to solve them, therefore there is a need for external intervention. The most appropriate definitions and categorization of natural disasters are the ones that have been made according to the physical causes of their appearance (geophysical, meteorological, hydrological, climatological, biological and astronomical). There are also those definitions that are based on quantitative indicators (the number of victims, the property insurance, the extent of necessary assistance) and others. Two organizations, Center for Research on the Epidemiology of Disasters (CRED), with its international database on disasters (EM-DAT), and insurance company, Munich Reinsurance Company (Munich RE), which is a database NatCatSERVICE, have striven for years to present a standardized definition that will be adopted at the global level, and in order to avoid terminological disharmony and to create a uniform classification. In 2007, CRED and Munich RE, reached an agreement on the classification of natural disasters, in order to provide the conditions of its most effective application for the purpose of monitoring, registration, prevention and operational goals in critical situations (Lukić et al, 2013).

In the Republic of Serbia, disasters are treated through two pieces of legislation: The Law on emergency situations in the Republic of Serbia and The National strategy for protection and rescue in emergency situations from 2011. In the Law on emergency situations, there is no definition of natural disasters, but instead the following terms were used: disasters, emergency situations and elementary disasters. Elementary disaster in this Act is defined as an event of hydrological, geological or biological origin, caused by action of natural forces such as earthquakes, floods, flash floods, storms, heavy rain, atmospheric discharges, hail, drought, landslide or mudslide, snow drifts and avalanches, extreme temperatures, ice accumulation on the watercourse, epidemic of infectious diseases, epidemics of animal diseases, the emergence of pests and other natural phenomena of major proportions, that may endanger the health and lives of people or cause severe damage.

The classification and definition are not in accordance with CRED and Munich RE. In the mentioned legal act of the Republic of Serbia, there are no types of climate disasters (although drought is mentioned as its subtype), hydrological and meteorological disasters are classified into one group. Invalid hierarchical classification, as well as large deviations compared to ones by CRED and Munich RE, hamper monitoring, registration and evaluation of the effects of natural disasters in Serbia.

Natural disasters make a negative impact on many economic activities (agriculture, energy, water management, construction, transportation, tourism and others). One of the sector that is 'vulnerable' when this phenomenon occurs is agriculture.

Drought is a natural disaster that is characterized by the deficit of rainfall, as well as by the lack of moisture in soil, which is necessary for normal growth and development of plants. In the meteorological service of the Republic of Serbia, drought is considered as a “steady stream of more then ten days, in which recorded daily rainfall is equal to or lower than 0.1mm“. As such phenomenon, it causes losses in crop production in areas in which it occurs. Detailed methodological overview of the effects of drought in agricultural production can only be done when comparing the production effects of cultivated crops in natural conditions and irrigation conditions (Šimunić et al, 2007). This paper analyzes the impact of the drought, established on the basis of one indicator - the SPI index, on the yields of certain field crops in Nišava District. According to data from the Republic Hydrometeorological Service of Serbia, which conducts drought monitoring, based on SPI index, the value of this index established for the period, can be used as an indicator of agricultural drought. The administrative territorial unit, Nišava District, was chosen due to availability of statistics on crops production. The aim of this paper is to establish the relevance of the impact of drought on the yield movements of certain field crops in Nišava district in the period 2006-2013.

2. The concept and definition of drought

The very name 'drought' has different meanings depending on the people, their background and interests. Many scientists have different perceptions of drought. Walker (1998) believes the drought is a rare occurrence, while Sharma (1998) believes that droughts is frequent on the

Earth (Jankovic, 2009). There is a difference between aridity and drought. While aridity as a phenomenon means that there is a constant shortage of rainfall in a region, compared to the necessary values, drought is a short-term deviation of precipitation and air temperature from normal values, for the given area and time of year. Legislation in Serbia does not distinguish clearly between natural disasters such as drought and aridity as a long-term drought indicator (Lukić et al, 2013).

Drought is a complex natural phenomenon whose definition requires the inclusion of the climate elements (the amount of slopes, air temperature, air pressure, wind speed, etc.), as well as hydrological factors (the level of surface and groundwater), soil (the type of soil), biological factors (presence and type of land cover), geographical and other factors. Therefore, they established numerous simplified definitions of drought, as well as its division into: atmospheric, hydrological, land and agricultural drought.

The definition of drought depends on regional differences and needs, but also on the perspective this phenomenon is observed from. Regardless of the needs of defining the drought, it is necessary to include deviation of the actual relationship between rainfall and evapotranspiration in the area, from the normal value of this relationship in a multi-year period. The definitions of drought can be divided into: conceptual and operational. Conceptual definition generally explains the concept of drought, while operational definition needs to offer easier identification of the beginning and the end of drought as well was its and intensity.

Drought caused by natural climate changes that lead to a lack of rainfall in a period, is recognized as the *meteorological drought*. The lack of rainfall through the hydrological circle, in combination with high evaporation losses can lead to land infertility and that represents *agricultural drought*. Lowering the water level of navigable rivers, as well as draining underground aquifers, represents a *hydrological drought*. Precipitation deposited as snow and freezing rivers cause *winter drought* (Tallaksen & Hisdal, 1997).

3. Geographical position of Nišava District

Nišava District extends approximately between 43º10' and 43º40' north latitude and 21º30' and 22º10' east longitude. Accordingly, as the entire territory of Serbia, Nišava District stretches in the middle of the northern temperate zone. According to the Regulation on the Nomenclature of

Territorial Units, Nišava District belongs to the Region of Southern and Eastern Serbia, as one of nine NUTS3 territories ("RS Official Gazete", No.109/09 & 45/10). Territory of Nišava District covers following administrative units: the City of Niš and its municipalities (Medijana, Pantelej, Crveni Krst, Palilula and Niška Banja) as well as, the municipalities of Aleksinac, Doljevac, Merošina, Ražanj, Gadžin Han and Svrljig. The total area of Nišava district is 2.728 square kilometers. In 2012. there were 374.371 residents living in this area (Municipalities and Regions in the Republic of Serbia, 2013). The territory is located between Pomoravlje and Zaječar District in the north and north-east, Pirot District in the east, Jablanica and Toplica District in the south and south-west and Rasina District in the west.

Regional position and geographical position of the study area are complex and diverse. Observed territory includes a number of smaller physical geographic regions. The most dominant recess in the land relief is valley of Niš and Aleksinac, which is surrounded by mountains of medium height. Zaplanje (in the basin of Kutinska River) and Svrljiška valley (in the basin of Svrljiški Timok), are also significant, as well as Dobrič, which extends in the lower part of Toplica basin.

The City of Niš as well as municipalities of Aleksinac and Ražanj belong to South Morava Valley. The municipalities of Doljevac and Merošina are in Dobrič (Toplica), Gadžin Han is in Zaplanje, while Svrljig municipality is in the south part of Carpatho-Balkan region. Therefore, the territory of Nišava District includes several geographic micro-regions of Eastern and Southern Serbia.

Spatial distribution of administrative units within the Nišava district, indicates the complexity of the physical and regional geographic position of the area.

According to Rakićević, in terms of drought, the territory of Serbia can be divided into four areas:

- *Dry areas* (areas most affected by drought): valley of Niš, Leskovac, Bela Palanka, Aleksinac, Vranje and Gnjilane, Dobrič, plateau of Kosovo, Metohija, area of Negotin, northeastern part of Bačka and northern Banat.
- *Moderately dry areas*: Srem, western and southern Bačka, southern Banat, Mačva, Podunavlje, valley of Great and Western Morava and most of Šumadija.

- *Moderately moist areas*: Podrinje, the foothills of Valjevo mountain range, mountain areas till the 1000m altitude in western and southeastern Serbia, as well as Carpatho-Balkan mountains in Eastern Serbia.
- *Very humid areas*: the highest mountain regions of Serbia, represented by: Šara mountain, Prokletije, high mountains of Stari Vlah, Kopaonik, Stara planina and Vlasina region.

This division was based on the analysis of the most important parameters which determine duration, frequency and intensity of drought. These are: annual precipitation, pluviometric regime, temperature and humidity in the vegetation period and the lack of moisture in the soil (Dragićević & Filipović, 2009).

Figure 1. Administrative Districts of Serbia with Nišava District (www.nis.okrug.gov.rs)
Regional distribution of drought in Serbia

Based on Figure 2, it can be concluded that most of the Nišava District belongs to the areas which are most affected by drought. These are the areas within a yearly isohyets of 600mm.

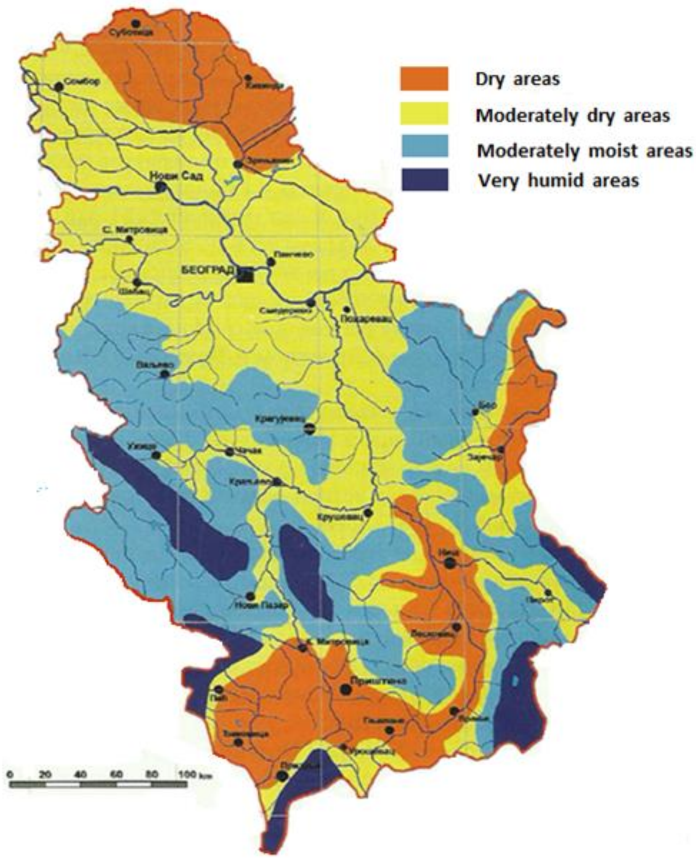


Figure 2. The regional distribution of drought in Serbia (Rakićević, 1988)

4. Indexes of drought

There are several indexes that show how the amount of rainfall and its distribution in the reporting period deviate from the average rainfall for at least thirty years, for the given time unit. Neither the one of them is superior to others, and most experts use different indexes to define the research results. The most commonly used indexes are:

- *De Marton Index* which establishes a link between rainfall, temperature and humidity of some areas (Ducić & Anđelković, 2004). Whereas vegetation depends on the amount of rainfall and air temperature, De Marton introduced this concept to demonstrate the connection between these two elements and the type of landscape in terms of moisture of vegetation.

- *Palmer Drought Severity Index* (PDSI) is based on the principle of balance between the need and the supply of the land with moisture. For determining the intensity of droughts, PDSI uses data on temperatures and precipitation. This index is more efficient in determining the long-term drought, but it is unsuitable for short-term synoptic forecasts (Dragićević & Filipović, 2009).
- *Percentage deviation* (Percentil) is calculated as the ratio of actual and normal (average for at least 30 years) precipitation amounts in the observed time period, multiplied by 100%. It is determined for any time unit, the vegetation period, hydrological years and others (Janković, 2009).
- *Standardized Precipitation Index* (SPI) is based on a calculation of the probability of precipitation for the selected time period. In addition to being able to calculate probability of precipitation for different time periods, this index can provide early warning of drought and help in assessing the intensity of the drought.

5. Standardized Precipitation Index – SPI index

The Standardized Precipitation Index (SPI) is a tool which was developed primarily for defining and monitoring drought. It allows an analyst to determine the rarity of a drought at a given time scale (temporal resolution) of interests for any rainfall station with historic data. It can also be used to determine the periods of anomalously wet events.

Standardized Precipitation Index is very applicable indicator of humidity conditions. Its calculation requires only data on the amount of rainfall. Standardized Precipitation Index is, in fact, the amount of rainfall recorded during a period of time represented by the value of the random variable that has standardized normal distribution of probabilities.

The notion that rainfall has different influence on the underground water level, the moisture content in the soil, as well as on water courses, has prompted Mc Kee, Doesken and Kleist to develop standardized precipitation index in 1993. This index is designed with the idea to quantify the precipitation deficit for different time periods (Redmond, 2002). Selection of the time period at the same time reflects the period in which the impact of drought on the availability of moisture can be noticed in different aquatic resources. Namely, the moisture content in soil is changed during the shorter period of time (due to appearance of anomalies in the precipitation regime), than in the surface and the groundwater, which react only to the long-term rainfall anomalies. For these reasons, SPI index calculation by Mc Kee and associates, was initially for a period of 3.6.12.24 and 48 months.

Calculation of SPI index for any location is based on the report on the long-term rainfall for the selected period. Positive SPI values indicate greater than average precipitation, and negative less than average precipitation.

In 1993, Mc Kee, Doesken and Kleist defined the criteria for the occurrence of drought for any period of time. The case of drought happens at any time when the SPI is continuously negative and reaches an intensity of -1.0 or less. This event ends when the SPI becomes positive.

Therefore, each case of drought has a duration that is defined from the beginning to the end. Also, it has intensity for each month in which drought is repeated. Positive sum of SPI indexes for all months with the case of drought, could be called "the size of the drought".

Monitoring moisture conditions carried out by the Republic Hydrometeorological Service of Serbia within the Department of Agrometeorology, includes the determination of SPI values on the basis of the amount of rainfall recorded in the previous 30, 60 and 90 days. Beside these, SPI values are also calculated for previous 1, 2, 3, 4, 5, 6, 9, 12 and 24 months. SPI values, established for longer periods of time, indicate the prevailing characteristics of moisture conditions during the vegetation season, the calendar year and so on.

Table 1. Humidity conditions and the value of SPI index (Hydrometeorological Institute of Serbia, Agro Climate)

Insignia	Humidity conditions	SPI values
ED	Exceptional drought	SPI≤-2.326
EXD	Extreme drought	-2.326<SPI≤-1.645
SD	Severe drought	-1.645<SPI≤-1.282
MD	Moderate drought	-1.282<SPI≤-0.935
D	Drought	-0.935<SPI≤-0.524
N	Normal humidity terms	-0.524<SPI<+0.524
SIH	Slightly increased humidity	+0.524≤SPI<+0.935
MIH	Moderately increased humidity	+0.935≤SPI<+1.282
VW	Very wet	+1.282≤SPI<+1.645
EXW	Extremely wet	+1.645≤SPI<+2.326
EW	Exceptionally wet	SPI≥+2.326

6. Materials and methods

Data on the production of field crops in Nišava District are taken from the website of the Republic Institute for Statistics of Serbia (www.stat.gov.rs). Field crops covered by the survey are: maize, wheat, rye, barley, oats, triticale and sunflower. In addition to data on the total yield of the observed cultures in tones, the analysis also shows the average yield in kilograms per hectare, as well as sown areas with field crops in hectares. SPI index values and data on the production of field crops were monitored from 2006. to 2013.

Table 2. Total production of field crops in the area of Nišava District (www.stat.gov.rs)

Year		maize	wheat	rye	barley	oats	tritica-le	sun-flower
2006.	Sown area (ha)	31891	22189	251	2668	1583	1069	7
	Average yield (kg/ha)	3658	2709	1924	2201	1698	2973	1714
	Total yield (t)	42794	31261	483	5871	2688	3140	12
2007.	Sown area (ha)	30392	22369	185	2572	1561	1297	7
	Average yield (kg/ha)	1208	1888	1276	1767	1401	2275	1000
	Total yield (t)	37381	42235	236	4545	2187	2951	7
2008.	Sown area (ha)	31620	20173	179	2688	1595	1285	105
	Average yield (kg/ha)	3879	3818	2330	3060	2320	3949	1524
	Total yield (t)	122639	77025	417	8226	3700	5074	160
2009.	Sown area (ha)	30400	21262	153	2436	1652	1505	8
	Average yield (kg/ha)	4051	3090	1889	2560	1944	3176	1875
	Total yield (t)	123159	65688	289	6236	3212	4780	15
2010.	Sown area (ha)	30500	20328	134	2285	1632	1647	4
	Average yield (kg/ha)	4100	2900	2100	2400	1800	3200	1000
	Total yield (t)	125814	59805	279	5523	2877	5298	4
2011.	Sown area (ha)	29703	20406	144	2334	1405	1580	5
	Average yield (kg/ha)	2900	3000	2300	2700	1900	3100	2000
	Total yield (t)	86110	61830	331	6221	2615	4926	10
2012.	Sown area (ha)	30312	19945	130	2279	1387	1453	5
	Average yield (kg/ha)	1900	2900	2000	2400	1600	3100	2000
	Total yield (t)	57720	58619	267	5509	2264	4543	10
2013.	Sown area (ha)	30333	20325	128	2325	1387	1682	6
	Average yield (kg/ha)	-	3595	2233	2884	2054	3751	-
	Total yield (t)	-	73145	268	6668	2761	6309	-

Data on SPI values are taken from the Republic Hydrometeorological Service of Serbia website (www.rhmz.gov.rs). They refer to the SPI calculated for six-month period. The study focused on two annual periods: the growing season, which runs from April to September, and the fall-winter period, which runs from October to March.

Table 3. Humidity conditions in Nišava District for the vegetation period (April-September), (Hydrometeorological Institute of Serbia, Agro Climate

Year	Vegetation period
2007.	Moderate drought (Severe drought in the valley of Niš)
2008.	Normal humidity conditions
2009.	Normal humidity conditions
2010.	Normal humidity conditions
2011.	Severe drought
2012.	Normal humidity conditions
2013.	Severe drought

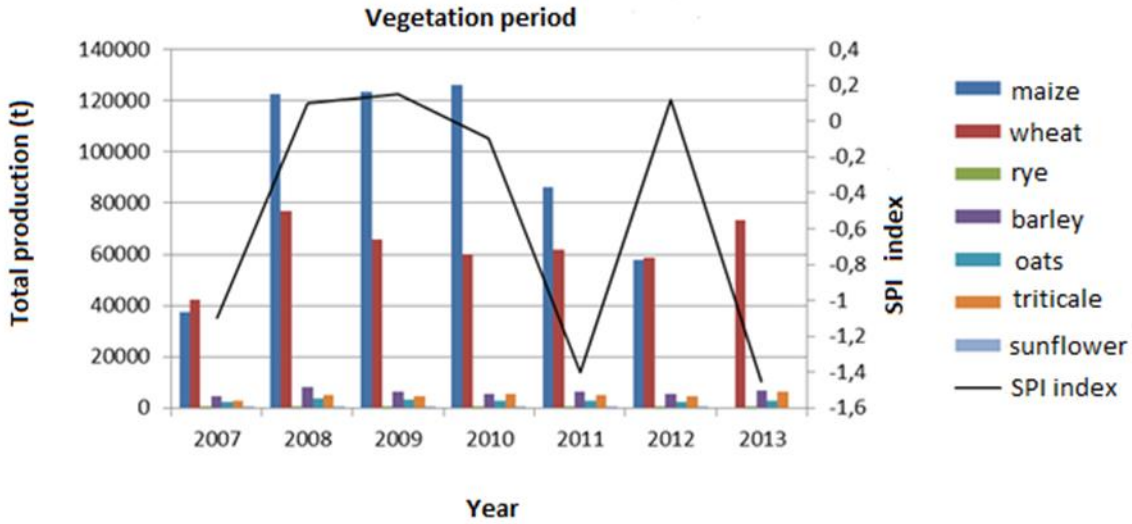
Table 4. Humidity conditions in Nišava District for the autumn-winter period (October-March) Hydrometeorological Institute of Serbia, Agro Climate

Year	Autumn-winter
2006/2007.	Drought
2007/2008.	Very wet
2008/2009.	Slightly increased humidity
2009/2010.	Exceptionally wet
2010/2011.	Normal humidity conditions
2011/2012.	Normal humidity conditions
2012/2013.	Moderately increased humidity

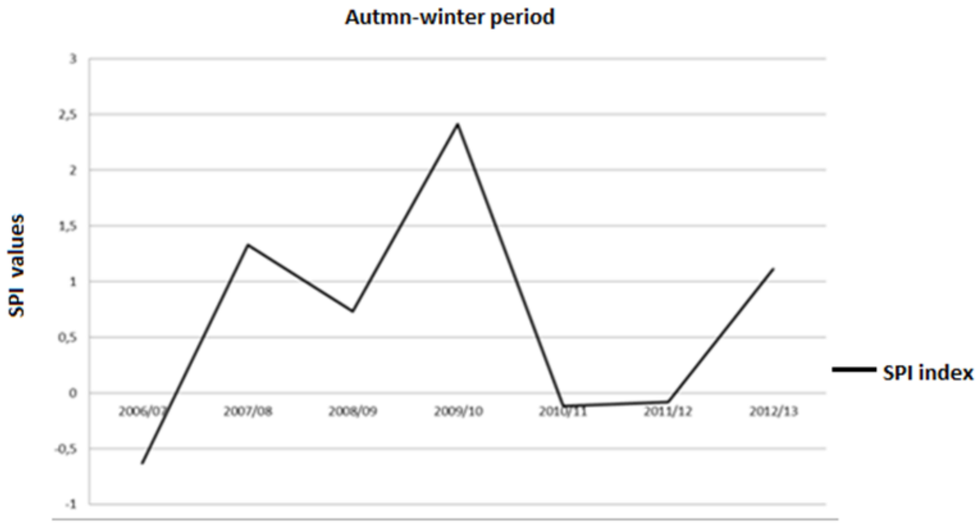
7. Research results

Data analysis indicates that in the years with the phenomenon of severe drought (2007, 2011, 2013) yield of field crops reduced. This phenomenon is most evident in the case of maize.

In 2007, in which phenomenon of moderate drought was registered (but in the valley of Niš severe drought was registered), yield of maize decreased by 70%, compared to 2010. (normally wet), which is also the most productive year in the period from 2006. to 2013. In that year, there was a high correlation between the SPI index and the yields of maize. In 2011, yield of maize was 31.6% lower then in 2010. However, in 2012, which had a normal moisture conditions, yield of maize was 54% lower then in the most productive 2010. Therefore, in this year, the reduction of maize yield was not conditioned by drought.



Graph 1. The ratio of the total production of certain crops and SPI index in Nišava District



Graph 2. The value of SPI for the autumn-winter period (2006-2013)

In the case of wheat, the results indicate that the yield less varied in the period from 2006. to 2013. Yield of wheat in 2011. and 2013. (which had a drought in the vegetation period) are even higher than in 2010. and 2012. (normal humidity conditions during the vegetation period). In this case, there is no correlation between SPI index in the vegetation period and the yield of wheat. For yields of wheat humidity conditions during the autumn-winter period are more important. In the period from 2006. to 2013., drought in autumn-winter period only occurred during 2006/07, while in other periods, normally or moderately increased humidity conditions prevailed.

Given the fact that the area sown with maize and wheat in Nišava District, makes up almost 90% of the total area under the field crops, the share of other analyzed cultures, is not significant for monitoring the impact of the SPI index on the movement of yields.

8. Discussion

Based on the research results, it can be concluded that there is certain impact of drought (established on the basis of the SPI index) on the yields of crops in the area of Nišava District, during the observed period. The reduction of maize yields does not always coincide with a period of drought defined by the negative values of SPI index during the vegetation period - when this culture needs the maximum amount of moisture. When it comes to wheat yield movements, it is noted that yields have a lesser variation of value in the period from 2006. to 2013. In some years, when there was a drought during the growing period (2011 and 2013), wheat yields have achieved higher values than in the normal wet years (from April to September). However, in the fall-winter period (October-March), in the Nišava District (except for 2006/07), there was the absence of drought. For the wheat yield the amount of precipitation during the sowing period is of crucial importance, as well as period before sowing, which is usually in September or October. Given that fact, in the case of wheat a correlation between the SPI index and the yield can also be established. Other crops that are analyzed in this paper are not relevant for monitoring the impact of the SPI index on the movement of yields, because the percentage of participation of their respective plantations is slight, compared to the dominant cultures (maize and wheat).

In comparison to other economic activities, agricultural production is characterized by dependence on a large number of natural factors, especially on soil, as well as on yearly climate conditions and on localities. In the fight against uncontrollable natural conditions, of mitigating the effects of adverse weather conditions should be take into account. In Serbia, drought is present almost every year in certain regions, with a greater or lesser intensity and it represents a limiting factor for high yields. According to some studies, with the use of agricultural procedures of small grains, the effect of "poor year" can be improved from 10 to 25%. Therefore, in order to reduce the risk of drought, appropriate measures of protection against drought should be taken (monitoring and early warning, risk assessment and mitigation of consequences).

References

Alley, W.,M. (1984): The Palmer Drought Severity Index: limitations and assumptions. Journal of Climate and Applied Meteorology, 23:1100-1109

Edwards, D., McKee T. (1997): Characteristics od 20th century drought in the United States at multiple time scales. Climatology Report 97-2.

Palmer, W.C. (1968): Keeping track of crop moisture conditions, nationwide: The new crop moisture index.Wetherwise 21: 156-161)

Redmond, K.T. (2002): The depiction of drought. Bulletin of the American Meteorological Society. 83, 1143-1147

Božić, M., Nikolić G., Milošev D. (2009): Suša i strategija navodnjavanja. Institut za vodoprivredu „Jaroslav Černi“

Volodin, A.,(1946): Velike i sušne pojave u prirodi, Prosveta. Beograd

Gavrilović, Lj. (2007): Prirodne nepogode kao faktor ugrožavanja životne sredine. Prvi kongres srpskih geografa. Zbornik radova. Beograd

Dragićević, S., Filipović, D. (2009): Prirodni uslovi i nepogode u planiranju i zaštiti prostora. Geografski fakultet Univerziteta u Beogradu.

Ducić, V., Anđelković, G. (2004): Klimatologija. Praktikum za geografe. Geografski fakultet Univerziteta u Beogradu

Maksimović, N.,A. (1946): Kako nastaju suše i možemo li se boriti protiv njih?, Beograd

Radenković, B. (1951): Borba protiv suša. Zadružna knjiga. Beograd

Šimunić, I., Husnjak, S., Tomić, F. (2007): Utjecaj suše na smanjenje prinosa poljoprivrednih kultura. Agronomski glasnik. Zagreb

Lukić, T., Gavrilov, B.,M, Marković, B.,S, M, Komac,B.,Z, Mlađan, D., Đorđević, J., Milanović, M., Vasiljević, A., Đ, Vujičić, D., Kuzmanović, B., M, Prentović, R. (2013): Classification of the natural disasters between the legislation and application: experience of the Republic of Serbia. Acta Geographica Slovenica, 53-1, DOI: 10.3986/AGS53301.

Komac, B., Zoran, M., Gavrilov, B.,M, Marković, B., S. (2013): Natural Hazards – some introductory thoughts. Acta Geographica Slovenica, 53-1, DOI: 10.3986/AGS53300.

Human resources as a competitive advantage in tourism development

Vidoje Stefanović[1], Selim Šaćirović[1], Nedžad Azemović[2],

[1]*University of Niš, Faculty of Sciences and Mathematics, Department of Geography*
[2]*ALFA University, Novi Pazar*

Abstract: Tourism itself, in the course of its development, experienced a great number of internal or external essential changes: it took and assumed different appearances and shapes, it was used in different means, it broadened its volume in spatial and quantitative sense, it changed structure and characteristics, enriched itself with new motives, received new functions, differently influenced the other aims and served different causes and targets, and while doing so, it never lost its economic characteristics. Modern mass tourism became the most important characteristic of this phenomenon and it has the core meaning in tourism research – especially in researching the economic effects and the influence on overall development. A glance at our current training programs or content of books and articles in the field of management, in addition to certain affirmation of principles of human resource management, shows us two tendencies of the negligence of the human resources. One of them is just a passing mention or no mentioning at all, as if not even noticed there is a new approach to the human component of business systems. The second tendency is shown by those who already realized that the human resources are a trend, so they bring the term in their texts and jargon, but more like a modern name for something already familiar. Therefore, if we want our siciety to properly use the doctrine of human resources, we have to persitently popularize its basic principles. So, what are those basic principles, or what is really new here?

Key words: Resources, Tourism, Development changes

1. Human resources in relation to other resources

Without people one organization couldn't possibly exist and function even when it is based on automatization of the highest level. Man is the one

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who puts life into one organization, moves and gives the sense and aims to the whole group of enterprise activity. People are the key business resources but at the same time they are simultaneously the most complex resources. This complex situation comes out of specific characteristics of human beings. Man is conscious and thoughtful being who has its own aims and life, which is not going on exclusively in the organization. So, for that reason, management of human resources is much more complex and requires more knowledge and skills than management of other resources. Because of the influence of other factors, it is hard to anticipate the final results, or the relation of input and output when human beings are in question. It is the reason why in the management of human resources the individual approach is necessary. Working result is the resultant not only of knowledge and skills, but the resultant of other numerous factors, individual internal factors as well as external, first of all organizational ones. But, human resources have extraordinary importance for organizational success. Exceptional importance of human resources can be seen in the following:[4]

Human resources, unlike other resources, can use their knowledge and creativity to put into operation all the biological, physical and other resources,

The synergistic effect, which only human resources possess, enables for the total operating result to be greater than the individual results; combining of individual abilities it is possible to receive qualitatively new organizational capabilities,

Behavioral and motivation factors allow increase or decrease of individual labor, and thus organizational results,

Only people possess **the creativity** and they can create a new non-standard products and services and provide organizational and personal development,

Uniqueness means that individual knowledge and skills are used in a specific way in each organization, which make organizational skills unique; this can't be copied and represents a competitive advantage,

The long-term effect assumes that human resources have a long-term impact on the performance of the organization and the implications of certain decisions and changes typically do not show up immediately in the

[4] More on: Pržulj, Ž. (2002) Management of human resources, BK Institute, Belgrade, p. 20

organizational reality, but with a "delay". That is why investment in human resources has long term effects,

Multiple implications reflect the organization's approach to human resources have simultaneously economic, social and health implications,

The ability of self-renewal and development means that human resources have almost unlimited internal development capability and this is the only resource that doesn't decrease with the usage, but increases,

Connection with all business functions confirms that all these functions depend on human resources, so the management of human resources has a direct impact on the quality of implementation of all business functions, and thus the organization as a whole,

The economic importance proves that the economic effects far outweigh the investments in human resources. Only a man with his work in the organization can create surplus value - the new value.

All this points to the need that the organizations should devote much more attention to human resources than to other resources. The interest of the organization for human resources is not primarily of a humanistic nature, but economic. However, it is understood that without respecting the human aspect of this resource, one can't get economic results. Therefore, the entire concept of human resource management is based on the principles of respect for human nature and connecting individual with organization goals.

People do not input into the organization only their qualifications and willingness to work, but also their personality and a part of their life. People bring their own perception of reality in the organization, their complexes, insecurity or arrogance, their desires, ambitions, anger, hatred, envy, dissatisfaction and everything can be turned into negative energy and destroy organizational goals. The task of human resource management is neutralizing such events and encouraging positive and creative energy. In contrast to the discipline of organizational behavior, dealing with "the study of behavior in organizations by systematically studying the individuals, groups, and organizational processes,"[5] human resources management has the task to discover, develop and launch human resources for the realization of organizational goals, while at the same working should bring personal satisfaction. Is this possible?

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[5] Grinber/Barn: «Behavior in organizations» Želnid», Beograd, 1998 page 6

We can't give a unique answer to this question, because the behavior in working atmosphere is a result of various factors, which makes it complicated. Even though there are no unique formulas or recipes, there is a certain level of possibility that some behavior will vanish in certain conditions. The management has the task to create favorable conditions for wanted behavior[6].

2. The specifics of human resources in tourism

Tourism, as a segment of the service sector, is becoming the "industry of the future". There are few economic activities that depend on the human factor like tourism. While other tertiary activities are characterized by a greater or lesser extent, the presence of the bidders and buyers in tourism, who rightfully face to face, the weight of that contact is characterized and emphasize those facts that can be classified under the common denominator of "hospitality" of tourists. Quality temporary tourist stay largely depends on the quality, therefore engagement, goodwill and training of human resources at all levels of hospitality. This immediately implies questions about how to perceive the importance of the human factor, as the carrier and the executor of tourist activity in an area, which is likely to be highly receptive, be it on the region or the entire country.

Considerations on the issue of the human factor in tourism should start with the question about the level of acceptance and what is the general attitude of the entire population of tourism. If the local population has expressed a positive attitude towards tourists, who come for a temporary stay in their community, one can say that there is an essential prerequisite for their quality relation or relation to quality hospitality. This is to point out the fact and the need to create the general conditions for creating a favorable atmosphere in accordance with responsible behavior towards tourists. A positive attitude towards tourism, above all, shows the degree of social and cultural development of the population of an area, which is a basic prerequisite for the development of tourism, in which everyone agrees.

[6] More in: Djordjević, B. (2001) *Psihologija menadžmenta*, Filozofski fakultet, Priština. In Serbian.

Consideration of the problem of human resources in tourism industry has a different weight when speaking about:[7]

- a space that has already reached a high level of tourist development,
- a space that is still developing,
- a space that only sees and plans its tourism development.

In most tourist destinations all the three features are present. The main question that arises is the question of sources of human resources. So, where to recruit the necessary personnel, are they present in the area viewed and how much we should turn to neighboring or distant sources. This is a seemingly simple question that, however, we should start looking for answers on key demographic characteristics of the area. This refers to the steady natural growth of population and tourism growth trends foreseen. This interdependence is extremely important, because we need to plan the mechanical inflow of population (eg. on islands).

Far more complex is the source of the problem of human resources in the areas of large concentration of tourist facilities. In this region, tourism is a priority activity, the headquarters of the economic and overall development, which gives complexity and multidimensionality. Here, the main accelerator and limiter of the overall development are human resources. In this respect, temporal dimension of human resources should be analyzed.

It should be repeated once again. There are two periods of business in tourism:

- Year-round operations - when facilities are available to tourists throughout the year regardless of the degree of capacity utilization; facilities are often located in large urban areas and, as a rule, have lower capacity utilization during the weekend or in the heat of the main tourist season,
- Seasonal business - when objects work for only a certain part of the year, while for the rest of the time they are closed; in principle, they operate during three different periods of intensity - preseason, season and postseason.

In order to highlight the complexity of human resources in tourism, it is necessary to emphasize the complexity of tourist offer, therefore the market position where the human resources work. Contrary to tourists - a large number of subjects of tourist offer (catering and hotel services, transport and trade, producers of souvenirs and other products for the tourist market) are there for the consumers. All of them, if generalized, make the tourist offer, which would mean that staff that provides these services should also be included in the tourism human resources.

So, tourism is a labor-intensive industry, as stated in plain language means that for performing an economic activity it takes a lot of human potential. Known fact about the impact of automation, electronics and similar to the reduction of personnel needed in tourism has only a limited impact, because in spite of all attempts to introduce modern technological and technical solutions in the business of tourism enterprises, the man, however, remains the main "producer" of the services. Modern technical aids mainly contribute to accelerating certain work processes, work technologies changes, but, as a rule, are less effective in reducing the number of employees, particularly in the hospitality industry. In other economic activities this impact is more pronounced. That shows the ratio of realized income and the number of employees in certain economy branch. For the same level of income (gross domestic product) it is necessary to engage more employees. With the same number of employees, tourism earns less income (Gross Domestic Product).

So, the fact is that hospitality and travel agencies require an increased number of employees relative to other economic industries. From these findings it is possible to draw a conclusion that the positive growth trend of tourist income inevitably entails considerably increased needs for new work potential. So one can conclude that tourism is a powerful new jobs generator. In addition, four main features that characterize the problem of human resources for tourism should be highlighted. Those are:[8]

a) A high level of employment of women,

b) High participation of under qualified personnel,

c) A high level of employment age,

d) The need for numerous seasonal demand.

a) As for higher participation of women, it should be repeated once again that the tourism is an "industry of hospitality", and in some ways, by basic characteristics is suitable for women. In the hotel industry households work (room hygiene, cleaning, washing and linen cleaning, serving food and drinks, especially the numerous tasks in the kitchen), is carried out mostly by women. This also applies to the front desk, cashier, administrative and accounting tasks. In operations of travel agencies also dominate women. In general, a large number of other services used by tourists are performed most often by female population.

[8] Boris Pirjevec, Principles of Tourism, Mikorad, Zagreb, 2002.g, p.139

Considering only the main characteristics of employment in tourism, it is necessary to emphasize the role and the place and the part of the female population that is outside the working contingent or outside the records of the employee part of the population. One should begin with a well-known fact that a good part of accommodation capacities are households or, more popularly - private accommodation. Although there is no statistical evidence of "employees" in this segment of accommodation, one could freely say that practically all tasks related to the operation of this form of accommodation are occupied by women. During the tourist season, the female part of the population, with their daily housekeeping obligations carry out many tasks related to the accommodation and service for customers, who are staying in their homes. It is this engagement that contributed to its great changes in the lives and cultural habits on the one hand, and on the other hand, it improved the living standards of families engaged in renting out their homes to foreign and domestic tourists.

b) The following main characteristic of employment in the tourism sector of the economy is the need for a high proportion of unskilled and semi-skilled human resources potential. There are a huge number of jobs which are not asking for special professional qualifications or complete education. In addition, it is known that the number of employees of such profile is inversely proportional to the category of accommodation facilities, ie. the higher category of the hotel building, it is in the structure of employment less those with lower qualifications. Because, to perform simple tasks, which are usually not in direct contact with guests, as a rule, there is a need for a large number of employees with lower qualification profiles (up to 20%). Of course, the question always arises as to whether and how to be with such a busy staff and provide quality services. High-quality services are the foundation of "hospitality industry".

Such a low qualification structure of employees, on the other hand shows that it takes relatively little time for their professional training and development. Therefore, the best way for their education is the principle of continuous education. It enables all the employees to quickly adapt to the radical changes in time and space, which are related to the growing needs of tourists. This will be discussed later.

c) Human resources in tourism are characterized by high levels of age structure of employees. From a macroeconomic point of view it is a reflection of the state of the economy and society and disorderly social policy. All those who can't follow the trends of modern knowledge and education remain without work engage in other industries, and thus seek salvation in the tourism industry.

On the other hand, tourism is an "industry of hospitality", which primarily requires dynamism, enthusiasm, cheerfulness and expertise of young people, who are ready to respond to anything and adapt to any challenge. The positive perception of a tourist destination or a pleasant first impression with tourists should be encouraged by young, ambitious, professional and ready (usually female) maidens with knowledge of several foreign languages and possessing a high quality information.

d) Travel movements are, as a rule, linked to certain seasons as the entire tourism industry imposes seasonal business. Seasonal business creates one of the biggest problems of tourism - the need for hiring seasonal staff. There are three main questions of the issues of "seasonal workers" who, as is well known, as a rule, do not live in tourist areas which are in need of these staff. Those are:

* necessary acquisitions of seasonal workers outside the place of employment,

* problem of their professional and educational profile required for a particular job,

* problem of adapting to their new living and working environment.

Seasonal workers are sought from among the ranks of the unemployed, or as temporary employees, who usually have no or have insufficient work experience in positions that are taken into temporary employment. It is not rare that they do not have enough aptitude for the job. Of course, here now comes the question of the quality of service. Seasonal workers who are not recruited from the native population, during their stay in temporary employment in a variety of ways include themselves in the labor and environmental practices of their new environment. These are very serious social problems, especially reflected in children.

Finally, a few words about the working conditions in the tourism industry. There is well known saying among employees in the tourism industry, and this work may be performed only by true enthusiasts, lovers of tourism and whose tolerance is very low. Tourism work takes place in several shifts, holidays, seasons, when temperatures are not exactly the most pleasant etc. The result is increased fluctuations in both permanent and temporary employees, but also the lack of interest of young people to their working career in tourism. However, it should be noted that these conditions differ in a positive performance of the tourist mediation, particularly in income, but only a tenth of the people working in tourism work here.

References

Bent, A. (1976) Demand Forecasting in tourism, University of Wales Press.

Bonisa, J. (1984) L'homme toujors le principel agens, Paris, 1984.

Boris, V. (2001) Toursm and Development, Mikorad, Zagreb.

Brekić, J. (1983) Personnel theory and practice, Informator, Zagreb.

Brekić, J. (1995) Innovative management, Alinea, Zagreb.

Brekić, J. (1992) Development and promotion of personnel, Globus, Zagreb.

Burns, P.H.A.(1995) Tourism, a new Perspective, Prentice Hall Int. London.

Dulčić, A. (2002) Management of tourism development, Faculty of Economy, Split.

Fennel, D. (1999) Ecotourism, Routledge, London and New York.

Graham, T.H., Bennet, R. (1998) Human Resources management, The Handbook Series, New York.

Gregor, Mc D. (1990) The Human Side of Enterprise, London.

Kavran, D. (1980) Planning of personnel, Economy Press, Belgrade.

Pirjevec, B. (2002) Principles of Tourism, Mikorad, Zagreb.

Radovanović, T. (1992) Personnel in market economy, Institute of Economic sciences, Belgrade.

Ratković, M. (2001) Development of human potentials, Teaching Faculty, Belgrade

Schultz, W. T. (1982) Investing in People, Los Angeles, London.

Schultz, W. T. (1980) Economic Growth and resources, Macmilian, London.

Stefanović, V. (2007) Human Resources in Tourism, PMF, Niš.

Stefanović, V. (2012) Economic effectiveness of human resource management, Beograd.

Vujić, V. (2004) Management of human potentials, Faculty of Hotel management, Rijeka.

The quality of water in the Nišava River in 2014

Tatjana Djekić[1], Dragana Vušković[2],

[1] *University of Niš – Faculty of Science, Višegradska 33, Niš, Serbia*

Abstract: The river Nišava is among the most significant natural resources of the town Niš. The water from the river Nišava is used for water supply, thus its quality represents a restraining factor in the further development of the town in terms of sustainable development. The objective of this paper is to demonstrate the quality of water of the river Nišava over the course of 2014. The comparative analysis of the concentration of nitrates and nitrites in the river Nišava is presented herein, in accordance with the Law on Protection of Nature (Official Gazette of RS, No. 36/9 and 88/10) and the Law on Waters (Official Gazette of RS, No. 30/10) of the Republic of Serbia, taking into account the current rule books of importance for understanding the relevant substances and values of their concentration in the samples of the water from the river Nišava.

Key words: nitrates, nitrites, ammonium ions, environmental protection, the river Nišava.

1. Introduction

The United Nations Conference on sustainable development „Rio+20"(UNCSD), held on 20 - 22 June 2012 in Brazil was dedicated to 20th anniversary of the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992 and the 10th anniversary of the World Summit on Sustainable Development (WSSD) in Johannesburg. Seven areas, which require priority attention, have been accentuated yet during preparation for the Conference "Rio+20": decent jobs, energy, sustainable cities, food security and sustainable agriculture, water, oceans and disaster readiness. As water has being one of the seven priority goals and the Nišava River was in 2012 polluted by nitrates, nitrites and ammonium ions, the authors published in 2013 in the journal „Ecologica" the paper „Analyze of the quality of water in the Nišava River - problem of pollution by nitrates, nitrites and ammonium ions"(Djekić *et al.*, 2013). In that paper was presented the comparative analyze of the data obtained by the Institute for Public Health in Niš for concentrations of nitrate, nitrite and ammonium ions in the River

Nišava during 2012. This paper deals with the possibility of still revealed pollution. It needs to be emphasized that the pollution by nitrate, nitrite and ammonium ions of the River Nišava represents very serious and the biggest ecological problem in Niš. Not less important is the fact that the year 2014 was extremely rainy, recording the highest precipitation since 1951 and that the spring season recorded the most rainfall within the last 120 years. In May 2014 the three days-lasting rainfall exceeded the thousand years mean values. The dominant property of climate in 2014 in the area of the Republic of Serbia was the extremely high precipitation rate
(http://www.sepa.gov.rs/download/Izvestaj2014.pd , page 38.).

2. Investigation Methods

Compare of the data obtained through monitoring by the Institute for Public Health in Niš was done in 2014 (http://www.izjz-nis.org.rs/higijena/akt_nisava.html). Physical-chemical analyses included a standard analytical techniques proposed by the law regulatives, and applied in the Institute for Public Health in Niš (Regulation on dangerous substances in water „Official Journal of the Republic of Serbia", no. 31/82). Investigations of the water quality in the Nišava River are conducting seasonally, and during summer more often (monthly), at five places. Measuring places are:

1. River Nišava – village Prosek – dam,
2. River Nišava at level of the water-capture Public Communal institution (PCI) „Naisus“,
3. River Nišava, 100 m upstream from the mouth of the main and helper sewage collector of Niš,
4. River Nišava, 300 m downstream from the mouth of the main and helper sewage collector of Niš,
5. River Nišava 100 m upstream from its discharge in the South Morava River.

3. Results

According to valuable legal and sub-legal acts the obtained results were analyzed: Water resources law (Water resources law „ Official Journal of the Republic of Serbia", no 46/91, 53/93 and 54/96), Water regime law („Official Journal of the Republic of Serbia", no. 59/98 and „ Official Journal of the Republic of Serbia", no. 101, 2005.), Regulation of dangerous substances in water („Official Journal of the Republic of Serbia", no. 31/82). According to the last cited (Regulation of dangerous substances in water; „ Official Journal of the Republic of Serbia", no. 31/82), maximal allowed contcentracions (MDC) for the I and II classes ammonium ions - 1.0 mg/L, nitrate - 10.0 mg/L, nitrite – 0.05 mg/L. MDK for the III and IV class is 10.0 mg/L for ammonium ions, 15.0 mg/L of nitrate and 0.5 mg/L nitrite. Results obtained during investigations at different localities are given in tables 1, 2 and 3, as well as at graphic presentation. According to the already mentioned "Regulation of dangerous substances in water" („Official Journal of the Republic of Serbia", no. 31/82), the obtained results suggest on:

1. River Nišava – village Prosek – dam

According to quality of water and concentrations of nitrate and ammonium ions, the Nišava River referred during the period of study to the first and II class (tables 1 and 3). However, the nitrite concentrations in March, August and October considered it into III and IV class. The nitrite concentrations in other months remain in the range of I and II class (table 2).

2. River Nišava at level of the water-capture Public Communal institution (PCI) „Naisus"

According to quality of water and concentrations of nitrate the Nišava River referred during the period of study to the first and II class (table 1). According to concentrations of nitrite and ammonium ions only in August considered it to III and IV class, while for all other months fits to I and II class (table 2, 3)

3. River Nišava 100 m upstream from the mouth of the main and helper sewage collector of Niš

According to quality of water and concentrations of nitrate the Nišava River referred during the period of study to the first and II class (table 1). The nitrite concentrations in March, July and August as well as the concentrations of ammonium ions in November considered it into III and IV class. These concentrations in all other months fits to I and II class (tables 2, 3).

4. River Nišava 300 m downstream from the mouth of the main and helper sewage collector of Niš

During the period of study the water from the Nišava River was in III and IV class by the quality, as well as by the concentrations of nitrate in August, and by nitrite concentrations in March, July, August and November. The same classes determined the concentrations of ammonium ions in July, August and November. In other months these concentrations referred I and II class (tables 1, 2 and 3).

5. River Nišava 100 m upstream from discharge in the South Morava River

Table 1 – Results of monitoring the nitrate (mg/l) concentration in samples of water from the Nišava River in 2014

Date of sampling	1.River Nišava village Prosek - dam	2.River Nišava at level of the water-capture, JKP NAISSUS	3.River Nišava 100 m upstream from the mouth of the main sewage collector	4.River Nišava 300 m downstream from the mouth of the main sewage collector	5.River Nišava 100 m upstream from discharge in the South Morava River
26/03/2014	5.2	4.7	4.4	4.4	5.2
12/06/2014	3.9	3.6	3.6	4.3	4.4
10/07/2014	3.9	4	3.9	3.7	4.4
06/08/2014	4	4.7	4.3	**12.96**	4.9
11/09/2014	4.57	2.73	2.8	2.67	2.7
12/11/2014	5.8	5.7	5.8	5.3	6.3

Table 2 – Results of monitoring the nitrite (mg/l) concentration in samples of water from the Nišava River in 2014

Date of sampling	1.River Nišava village Prosek - dam	2.River Nišava at level of the water-capture, JKP NAISSUS	3.River Nišava 100 m upstream from the mouth of the main sewage collector	4.River Nišava 3300 m downstream from the mouth of the main sewage collector	5.River Nišava 100 m upstream from discharge in the South Morava River
26/03/2014	**0.13**	0.05	**0.09**	**0.09**	**0.09**
12/06/2014	0.035	0.035	0.03	0.04	0.035
10/07/2014	0.02	0.02	**0.08**	**0.08**	0.04
06/08/2014	**0.15**	**0.15**	**0.15**	**0.4**	**0.4**
11/09/2014	0.05	0.03	0.03	0.04	0.04
12/11/2014	**0.06**	0.04	0.08	**0.1**	**0.2**

*Source: Institute for public health in Niš

During the period of study the water from the Nišava River was in the I and II class due to concentration of nitrate. The concentration of nitrite in March, August and November, including the concentrations of ammonium cations in August and November classified it into the III and IV classes. The concentration of nitrite and ammonium ions in other months corresponds to the I and II class.

Table 3 – Results of monitoring the ammonium ions (mg/l) concentration in samples of water from the Nišava River in 2014

Date of sampling	1.River Nišava village Prosek - dam	2.River Nišava at level of the water-capture, JKP NAISSUS	3.River Nišava 100 m upstream from the mouth of the main sewage collector	4.River Nišava 300 m downstream from the mouth of the main sewage collector	5.River Nišava 100 m upstream from discharge in the South Morava River
26/03/2014	<0.05	<0.05	0.45	0.45	<0.05
12/06/2014	0.15	<0.05	0.05	0.20	0.14
10/07/2014	<0.05	<0.05	1.0	**1.25**	0.50
06/08/2014	0.5	**5.25**	0.5	**1.25**	**1.25**
11/09/2014	0.05	0.05	0.1	0.15	0.40
12/11/2014	<0.05	<0.05	**1.50**	**3.75**	**1.75**

** Source: Institute for public health in Niš*

According to "Regulation of dangerous substances in water" (Official Journal of the Republic of Serbia, no. 31/82) the obtained results, which are presented in tables 1, 2 and 3 reflects that the nitrate concentration in spite fluctuations at measuring cites remains within the MDC range, except in August at the locality number 4. The nitrite concentrations varied in March, July and November, and in June were in allowed range. The nitrite concentrations in August exceeded proposed concentrations within all monitoring localities tending to decrease in September and reach the proposed MDC value. The concentration of ammonium ions was within the MDC boundaries at monitoring places 1, 2 and 3, excluding in August at the locality no. 2 when the highest amount of 5.25 mg/l was recorded and in November at monitoring place 3. At monitoring places 4 and 5 the same concentration fluctuated, whereas at the locality 4 exceeded MDC value in August and November. Monitoring of concentrations for ammonium ions, nitrate and nitrite clearly reflects on their mutual dependence in hydrodynamic processes in water, i.e. that the increasing concentration of ammonium ions leads to decreasing concentration of nitrate and nitrite, and opposite. Such trend is obvious at tables 1, 2 and 3. The estimated data suggests on connection between concentrations of nitrate, nitrite and ammonium ions with the level of the Nišava River and discharge of waste water from the main sewage collector. Results of laboratory researches on the hygienic suitability of water from the Nišava River within the territory of the Niš city is in agreement with proposals of the "Regulation of dangerous substances in water" (Official Journal of the

Republic of Serbia, no. 31/82). Therefore, it can be concluded that the highly fluctuated quality of water in the Nišava River during the raised water levels is able to receive waste water without misbalances. However, during periods (months) of low water-level the Nišava River does not succeed to clean waste waters itself and leave the places downstream from the discharge of waste waters from the main sewage collector in catastrophic situations.

4. Conclusion

The all above mentioned statements lead to conclusion that the River Nišava owns a water of good quality, as had owned in 2012 in spite the extremely high level in May 2014. Unfortunately, a water in the River Nišava downstream from the discharge of waste waters from the main sewage collector during months of low water level remains polluted with nitrates, nitrites and ammonium ions. Pollution of the water in the River Nišava is the biggest ecological problem in Niš (Djekić *et al*. 2013). The necessity for continual monitoring of the volume of waste water discharging from the city's sewage system into the recipient - River Nišava is already incorporated into the budget founds for the environmental protection of Niš in 2015 as well as the proposals for projection of purification systems. (http://www.ni.rs/wp-content/uploads/150224-122-11.pdf)

References

Institut za javno zdravlje grada Niša. http://www.izjz-nis.org.rs/ pristupljeno 21. 09. 2015.

Pravilnik o opasnim materijama u vodama („Sl. glasnik RS", br. 31/82). http://pks.rs/SADRZAJ/Files/Komunalna/Zakonska%20regulativa/Vodovod/

Pravilnik o higijenskoj ispravnosti vode za piće („Sl. list SRJ", 42/98 i 44/99). http://www.vitezsertifikacija.rs/download/pdf/Pravilnik%20o

Đekić T, Srećković-Batoćanin D, Šaćirović S, Stanković A, Gajić V (2013): „Jedan primer očuvane životne sredine – kanjon reke Zabave", „Ecologica", Beograd, br. 70.

Đekić T, Stanković A. (2013): „Analiza kvaliteta vode reke Nišave - problem zagađenjanitratima, nitritima i amonijum jonom", „Ecologica", Beograd, br. 71.

Council directive 98/83/EC on the quality of water http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1998:330:0032:0054:EN:PDF http://www.rdvode.gov.rs/doc/dokumenta/direktive-eu/2.%20Direktiva%2098-83-EC%20o%20kvalitetu%20vode%20za%20pice.pdf

Zakon o režimu voda („Sl. list SRJ", br. 59/98 i „Sl. glasnik RS", br. 101), 2005.

A method of spectral analysis of hidrological time series on the example of river Veternica discharge

Nataša Martić Bursać[1], Vladan Ducić[2], Radomir Ivanović [3], Ljiljana Stričević[1]

[1]*Department of Geography, Faculty of Science and Mathematics, University in Niš, Serbia*
[2]*Faculty of Geography, University of Belgrade, Serbia*
[3]*Department of Geography, Faculty of Science and Mathematics, University of Priština with the seat in Kosovska Mitrovica, Serbia*

Abstract: The time series provides crucial information for the analysis and identification of dynamical properties of a wide range of geophysical systems. Here we present the method of spectral analysis known as Fast Fourier Transformation (FFT) in case of river Veternica discharge series. Importance of proper decomposition of time series and preparation of data for analysis is emphasized. As a result we get the main periodicity in Veternica discharge.

Key words: discharge, Veternica, time series, decomposition, spectral analysis, periodicity

1. Introduction

The analysis of hydrological system variability realized in time series of observational data needs adequate statistical methods. The purpose of time series analysis is to determine some of the system's key properties by quantifying certain features of the time series. These properties can then help understand and predict the system's future behavior.

There are two general aspects of time series analysis, analysis in time domain and analysis in frequency domain. As the analysis in time domain, such as auto-correlation or cross-correlation analysis, are fairly familiar to physical geographers, principals of frequency domain analysis are mostly unknown. The aim of this paper is to discuss some practical aspects of time series analysis in frequency domain, using a study of river Veternica discharge series to illustrate some practical problems which can arise.

Spectral analysis includes many useful methods based on the Fourier analysis of the time series. The most fundamental is the estimation of the spectral density function, whose graphical representation is called periodogram (Bloomfield, 1976). Spectral analysis provides a frequency based description of the time series and indicates interesting features such as long memory, presence of high frequency variation and cyclical behavior (Percival et al., 1993).

2. Methodology

There is a collection of measured river discharge data, and the data are measured every day at the same time. Such collection of data is called daily discharge time series, and we shall denoted as q_n:

$$q_n = \{Q_1, Q_2, \dots, Q_N\}$$

where Q_k is measured discharge in day $k, k = 1.2, \dots, N$.

Averaging daily time series in time, we can easily derivate monthly or yearly time series.

Now we can ask the questions: is there any cyclicality in this time series and, if there is, what is the periodicity? Answering these questions is very important for predicting models of river discharge.

We define Discrete Fourier Transformation – DFT of time series q_n (McLeod et al., 1995):

$$DFT(q_n) = \{\hat{Q}_1, \hat{Q}_2, \dots, \hat{Q}_N\}$$

where

$$\hat{Q}_k = \sum_{n=1}^{N} Q_n e^{-i2\pi(k-1)\frac{(n-1)}{N}}, k = 1.2, \dots, N$$

Now we construct periodogram as a natural estimator of the spectral density function of q_n is presented as the modulus squared of the $DFT(q_n)$.

Examination of periodogram provides information of cyclicality and periodicity of time series. There are numerous algorithms of DFT calculation, but most important and widely used is FFT. FFT is implemented in various commercial software, such as MS Excel, MatLab, R, etc.

3. About river

In our analysis we used daily discharge series of Veternica River in Leskovac, in the period 1948-2012. Data are provided by Republic Hydrometeorological Service of Serbia (RHMZ).

Veternica is a small river which basin lies in south part of Serbia. River is formed by joining Manastirski and Jezerski creak on mountain Kitka. Veternica is a left tributary of Južna Morava (South Morava), with length of 75 km and catchment area of 515 km². Gauging station Leskovac is located 11 km from the mouth, covering 500 km² of Veternica catchment area. (Gavrilović, 2011). Veternica has a simple regime with maximum discharge occurring in March-April and minimum in August-September (Figure 2).

Figure 1: Gauging station Leskovac (Source: RHMZ)

Table 1: Main discharge parameters (1948-2012)

Observational period		N	F [km^2]	Q_{max} [m^3/s]	Q_{min} [m^3/s]	Q_{avg} [m^3/s]	σ	c_v	q [l/s /km^2]
1948.	2012.	65	500	216	0	3.98	6.49	1.63	7.96

Source: (Martić Bursać, 2015)

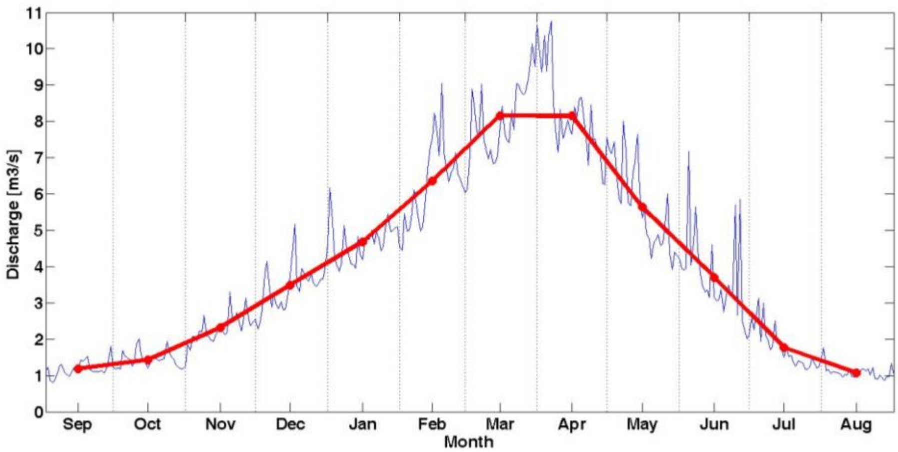

Figure 2: Hydrograph of Veternica (blue line – daily average, red line – monthly average)

4. Results and discussion

Applying FFT on river Veternica discharge series, we construct periodogram shown in Figure 3. It is obvious that spectral component with period of one year is highly dominant, so that the rest of the specter could be considered as a noise. This way of reasoning brings us to wrong conclusion (Ghil et al, 2002).

An important component of Earth climatological and hydrological data is the seasonal variation in the time series (Kawale et al., 2011). Seasons occur due to the revolution of the Earth around the Sun. The Sun is main energy source of climatic system, and dominant one-year spectral component in periodogram is consequence of repeating of the same energetic conditions during Earth's revolution. The seasonal component is the most dominant component in all climatological and hydrological data series with sampling period less than a year. As a result of such a dominant effect of seasonal patterns, other signals in the data are almost completely suppressed.

In order to solve the emerged problem, hydrological time series is decomposed into several components (Yevjevich, 1972, 1984). There are various ways to decompose time series. Here we adopt four element additive model of decomposition:

$$q_n = t_n + s_n + c_n + e_n$$

where t_n is a trend, s_n seasonal component, c_n cyclic component, and e_n is stochastic component or error.

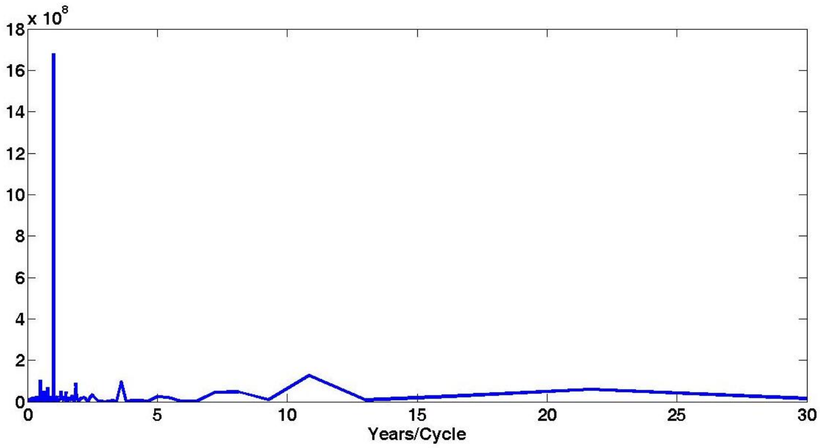

Figure 3: Veternica discharge periodogram (row daily data)

The trend represents long term changes, and its existence in the time series is checked with various statistical tests. Applying Man-Kendall test on data shows Veternica discharge has no significant trend in the observational period. In general, when we are interested in spectral analysis, if there is a trend it should be removed from time series. Numerous methods are proposed for detrending, one comparative analysis is given by Zhang and associates (Zhang et al., 2011).

The existence of a seasonal component depends on the type of data in a time series. As we have seen daily hydrological series has strong seasonal component. Removing seasonal component from time series is very important for proper analysis. What method of deseasonalization will be used depends on the type of seasonality we need to remove from time series (Ghil et al, 2002; Zhang et al., 2011; Douglass, 2011).

Most common method of removing seasonality that we are facing here is an average removing method (McLeod, 1995). The method consists of the following: first, we construct a matrix so that each column contains data from the time series that corresponds to a calendar year. The number of columns corresponds to the number of years of observation. After that we construct column vector as an average of each row. Constructed column vector contains daily averages in observational period. At the end we subtract daily average vector from every matrix column, and decompose the matrix in a time series in the same way that we formed. Resulting time series is deseasonalised.

Deseasonalization time series contains cyclic and stochastic component of discharge signal we often call anomaly.It is usual to normalize the anomaly to be comparable with the other proxies.

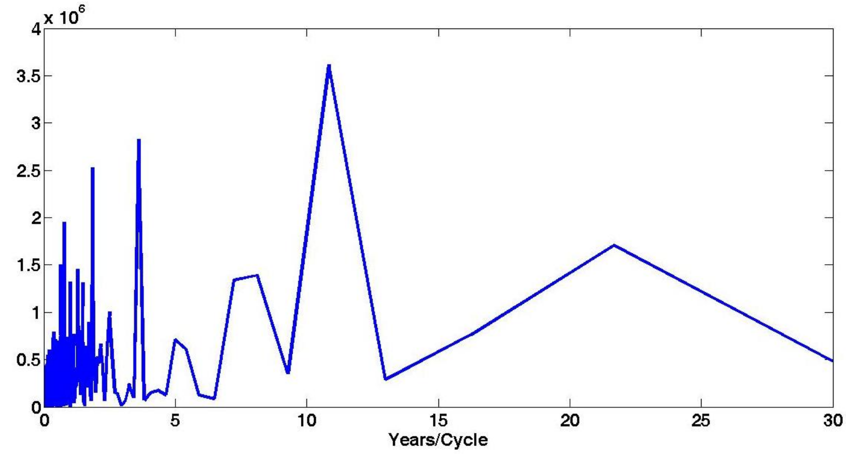

Figure 4: Veternica discharge periodogram (deseasonalised daily data)

Now we construct new periodogram by applying FFT on deseasonalised time series, which is shown in Figure 4. As we can see, after removing dominant spectral component rich specter of background processes is sappears. Every peak of periodogram represents period of cyclicity in discharge of Veternica.

5. Conclusion

In the study, we proposed FFT based periodogram analysis as a simple method for finding periodicity in discharge data.

Interannual cycles were found in Veternica discharge. Periodogram analysis of deseasonalised discharge time series reveals periodicity of 2.4; 3.6; 7-8; 20-24 years.

We have shown that even small streamflows as Veternica show periodic behavior. Such periods have been found in most of European rivers (Pekarova et al, 2003). Equality found in periods suggests that there is a common agent in the phenomenon. The source of this interannual cyclicity is unclear, but it has been shown that it may be linked to global climate indices, as NAO, ENSO, PDO, etc (Robertson, 1998; Labat, 2006, Martić Bursać, 2015).

North Atlantic Oscillation (NAO) and Artic Oscillation (AO) are the most prominent climate modifiers of northern hemisphere. It is shown that all the periods found in Veternica discharge are linked to a greater or lesser extent with NAO and AO (Hurrell, 1995). Unfortunately, these oscillations exhibit stochastic behavior with very low predictability (Gamiz-Fortis, 2002) so their usability in discharge models are low.

References

Bloomfield, P. (1976) Fourier Analysis of Time Series: An Introduction. New York, Wiley

Douglass, D. (2011) Separation of a Signal of Interest from a Seasonal Effect in Geophysical Data: I. El Niño/La Niña Phenomenon. International Journal of Geosciences, Vol. 2, p. 414-419.

Gamiz-Fortis, S. R., Pozo-Vazquez, D., Esteban-Parra, M. J., Castro-Dıez, Y. (2002) Spectral characteristics and predictability of the NAO assessed through Singular Spectral Analysis. Journal Of Geophysical Research, Vol. 107.

Gavrilović, Lj. Dukić, D. (2014) Reke Srbije. Zavod za udžbenike i nastavna sredstva, Beograd, str. 72.

Ghil, M., Allen, R., Dettinger, M., Ide, K., Kondrashov, D. (2002) Advanced spectral methods for climatic time series. Rev. Geophys. 40(1), pp. 3.1–3.41.

Hurrell, J. W. (1995) Decadal Trends in the North Atlantic Oscillation: Regional Temperatures and Precipitation. Science, 1995, Vol. 269, no. 5224, pp. 676-679.

Kawale, J., Chatterjee, S., Kumar, A., Liess, S., Steinbach, M. & Kumar, V. (2011) Anomaly Construction in Climate Data: Issues and Challenges, in Ashok N. Srivastava; Nitesh V. Chawla & Amal Shehan Perera, ed., 'CIDU' , NASA Ames Research Center, pp. 189-203.

Labat, D. (2006) Oscillations in land surface hydrological cycle. Earth and Planetary Science Letters 242 (2006), pp.143– 154.

Martić Bursać, N. (2015) Uticaj atmosferskih oscilacija na kolebanje proticaja reka u Srbiji. Prirodno-matematički fakultet, Univerzitet u Nišu.

McLeod, I., Hipel, K. (1995) Exploratory spectral analysis of hydrological times series. Stochastic Hydrology and Hydraulics, Volume 9, Issue 3, pp 171-205, 1995.

Pekarova, P., Miklanek, P., Pekar, J. (2003) Spatial and temporal runoff oscillation analysis of the main rivers of the world during the 19th-20th centuries. Journal of Hydrology 274, pp. 62-79.

Percival, D. B. and Walden, A. T. (1993) Spectral Analysis for Physical Applications, Cambridge University Press.

Robertson, A., Mechoso, C. (1998) Interannual and decadal cycles in river flows of southeastern South America. J. Climate 11 (1998), pp. 2570–2581.

Yevjevich, V. (1972) Structural Analysis of Hydrologic Time Series. Hydrology Papers, No. 56, Colorado State University, 1972.

Yevjevich, V. (1984) Structure of daily hydrologic time series. Water Resources Publications, 1984, Littleton, USA.

Zhang, Q., Zhou, Y., Singh, Y., Chen, Y. (2011) Comparison of detrending methods for fluctuation analysis in hydrology. Journal of Hydrology 400 (2011), pp. 121–132.

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