BASIC CHARACTERISTICS WATER REGIME AND WATER BALANCE OF THE RIVER UNA

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Under the river regime implies an average river water level, dictated by laws the average long-term situation of mutual physicalgeographical processes and phenomena, and are defined by the water level, flow of and runoff (Spahic, 2013). Applying the classification of river regimes, Slovenian geographer Ilesic S. (1947), the river Una is included in the group of the river with Posavina variant pluvio-nival regime. Considering the catchment area, or different climatic conditions, relief, geological structure and vegetation, in this paper, it has been proved that the river of Una regime and its tributaries has combined pluvio-nival regime with different variants.

Water regime in the Una is the result of several factors physicalgeographical environment. How much will a catchment area abound in water depends primarily on the quantity and distribution of rainfall. Using concrete scientific methods, depending on the physicalgeographical determinants in the Una river basin were analyzed hydrological parameters from the hydrological profile, primarily in Bosanska Dubica which is in the hydrological monitoring the most representative.

Article continuously follows research published in the previous issue of Acta, about izohyet and evapotranspiration elements in the Una, which was the basis for the study of river regime and water balance.

Keywords: *The River Una basin, physicalgeographical characteristics, river regime, the water balance*

INTRODUCTIONS

There are several definitions of river regimes, depending on the immediate area of interest of the author. So Ilesic S. (1947) states that under the river regime considered all those medium, regular hydrological phenomena with which we can count on the rivers more or less every year. Ovchinnikov AM (1955) indicates that the regime of the river called lawful fluctuations in the course of time all the elements of her life, but first of all levels and amounts of water. French hydrologist-geographer Pardo M. (1964) considers that the river regime is a complex phenomenon related to feeding watercourses and changes in their condition. Most acceptable definition given Spahic M. (2013), which under the river regime implies an average river water level, dictated by laws average long-term condition of mutual physical-geographic processes and phenomena, and defined by the water level, water flow and runoff.

Hydrological process, which takes place on a river basin, most credible can be analyzed and presented using data from the entire network of hydrological monitoring of the area. Optimal network of hydrological monitoring provides the ability to determine the temporal and spatial distribution of the analyzed hydrological parameter, and defining of its regime. As the main aim of the article assessment of river regimes and water balance in the basin of the Una River, it is necessary to treat all hydrological watermeters that have a

historical period of work at least from 1960 - 1991. According to the conclusion thirteenth session of the Commission for Climatology of the World Meteorological Organization (2001), in the use of a normal series of 1961-1990. year, so this 30-year period taken for analysis of meteorological parameters, especially rainfall, which directly affect the state of the river regime. In view of the initiation and duration of the work of individual water meters, in some cases, data were collected from the available observation period, as presented in Table 1.

Tab. 1. Water meters on the catchment area of Una

No.	HS	River	Period processing	Coordinates		Altitude (m)	Equipment	
				λ (° ′ ″)	φ (° ′ ″)		HS	Condition 2010th
1	Martin Brod - up.	Una	1961-1990	16 08 52	44 28 52	362,48	lath	-
2	Martin Brod - down.	Una	1953-1990 2004-2008	16 08 21	44 29 45	309,93	limnig raph	AS
3	Kulen Vakuf	Una	1961-1990 2007-2008	16 05 37	44 33 44	298,81	lath	AS
4	Strbački Buk	Una	1961-1990	16 01 05	44 39 18	293,17	lath	-
5	Bihać	Una	1949-1990 1998-2008	15 52 40	44 48 49	219,84	lath	-
6	Kralje	Una	1961-1990 2002-2008	15 51 02	44 50 02	208,85	limnig raph	AS
7	Bosanska Krupa	Una	1961-1990	16 09 29	44 53 06	149,98	lath	AS
8	Bos. Novi - up.	Una	1961-1990	16 22 41	45 02 59	116,06	lath	AS
9	Bos. Novi - down.	Una	1961-1990	16 23 18	45 03 19	116,06	limnig raph	AS
10	Bos. Dubica	Una	1961-1990	16 48 50	45 11 07	94,17	limnig raph	-
11	Drvar	Unac	1961-1990 2005-2008	16 23 18	44 22 50	463,51	lath	AS
12	Rmanj Manastir	Unac	1961-1990 2006-2008	16 08 48	44 29 37	314,66	lath	AS
13	Klokot	Klokot	2005-2009	15 48 36	44 49 23	209,854	lath	AS
14	Donja Pecka	Sana	1961-1990	16 50 36	44 19 05	401,32	lath	-
15	Ključ	Sana	1961-1990 2005-2008	16 47 56	44 31 50	246,93	limnig raph	AS
16	Vrhpolje	Sana	1961-1990	16 44 32	44 41 22	178,24	lath	-
17	Sanski Most	Sana	1952-1990 2001-2008	16 40 12	44 45 58	156,18	lath	AS
18	Prijedor	Sana	1952-1990	16 42 25	44 58 29	129,68	limnig raph	AS
19	Bos. Novi	Sana	1961-1990	16 23 18	45 02 58	116,26	lath	-
20	Hrustovo	Sanica	1967-1990	16 44 35	44 40 53	200	lath	AS
21	Omarska	Gomje nica	1961-1969 1973-1979	16 32 17	44 52 37	147,66	lath	-

According to the Commission for Hydrology of the World Meteorological Organization, in terms of the minimum number of watermeters, it is recommended that in the plain areas set one station for every 1000 - 2500 km^2, and in the mountains one station for every 300-1000 km^2. On the basis of these recommendations, it can be concluded that the basin of the Una, sufficiently covered hydrological monitoring. In the area of the Una basin is located 21 hydrological stations, of which is in the analyzed period were 15 watermeter laths and 6 limnigraph. At 13 locations measurement today is performed by automatic stations. On waterstream of the Una, with a length of 221.8 km, there are 10 water meters, of which is 6 automatic.

RESULTS AND DISCUSSION

Water level, flow of, runoff - elements of the Una regime

Water regime in Una river basin is the result of several factors, physical geographic environment. How much will a basin abound in water depends primarily on the quantity and distribution of rainfall. According Ilesic S. (1947), Una has Posavina variant pluvio-nival regime, with the highest water levels in April, and then in March, May and November, and the lowest in August and September. The analysis of the value of the water level on water meters during a 30-year period, it can be concluded that in Una river basin represented a combined pluvio-nival regime. The minimum and maximum water levels appear in the months characteristic for different variants. So the highest water levels appear in the following order: April, March, February, while individual water meters record these values in April and then in May and March. The second maximum is not in November as it is typical of the Posavina variant, than in December. The lowest water levels appear in August and September in most hydrological stations, while on two (Klokot and Drvar on Unac) they associated with July and August.

Tab. 2. Average monthly water levels in the basin of Una in cm (1961st to 1990th)

Water meters (river)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Martin brod -up. (Una)	121	124	125	129	120	113	105	101	104	111	119	126
Martin brod-down. (Una)	120	125	133	146	125	103	80,1	69,1	76,3	92,2	116	134
Kulen Vakuf (Una)	116	124	128	141	118	97,6	79,9	72,1	78,1	91,3	107	129
Štrbačk Buk (Una)	177	181	186	193	180	164	149	144	148	158	173	184
Bihać (Una)	28,9	33,9	35,8	41,6	32,7	22,5	13,3	8,0	10,1	17,0	27,8	35,2
Kralje -Bihać (Una)	162	171	182	202	173	140	115	106	109	129	151	175
B.Krupa (Una)	99,7	106	112	123	104	83,8	62,2	50,2	56,2	71,7	87,1	106
B.Novi -up. (Una)	171	173	184,	201	164	132	103	88,4	98,5	117	149	176
B.Novi-down. (Una)	103	116	138	160	115	71,1	32,3	8,0	17,9	45,1	83,2	119
Dubica (Una)	42,7	56,7	73,4	96,0	43,0	1,7	-31	-50	-43	-18	17,5	50,5
Klokot (Klokot)	155	141	183	204	129	105	76,9	79,5	85,3	98,7	122	191

Drvar (Unac)	**28,3**	**31,8**	**36,2**	**53,6**	**29,0**	**17,5**	**5,0**	**3,7**	**8,1**	**15,9**	**27,0**	**36,5**
Rmanj Manastir (Unac)	**103**	**106**	**118**	**141**	**119**	**88,9**	**61,4**	**45,2**	**54,0**	**69,5**	**95,9**	**116**
Donja Pecka (Sana)	**126**	**124**	**134**	**159**	**146**	**119**	**99,5**	**83,6**	**86,2**	**98,5**	**117**	**133**
Ključ (Sana)	**71,6**	**76,1**	**88,5**	**117**	**94,1**	**62,7**	**40,8**	**27,4**	**32,4**	**44,8**	**66,2**	**84,6**
Vrhpolje (Sana)	**82,4**	**87,7**	**97,3**	**117**	**97,5**	**72,7**	**55,6**	**44,4**	**49,5**	**59,7**	**75,9**	**92,6**
Sanski Most (Sana)	**171**	**178**	**191**	**209**	**188**	**164**	**147**	**134**	**139**	**150**	**167**	**183**
Prijedor (Sana)	**119**	**131**	**145**	**164**	**132**	**96,9**	**72,8**	**54,2**	**60,9**	**79,8**	**103**	**129**
Omarska (Gomjenica)	**127**	**144**	**129**	**131**	**117**	**109**	**95,1**	**86,1**	**88,1**	**97,3**	**110**	**133**
Hrustovo (Sanica)	**86,4**	**94,0**	**108**	**119**	**94,8**	**83,0**	**66,4**	**59,1**	**65,9**	**73,5**	**84,1**	**98,7**

Source: Hydrometeorological Institute of FB&H, Sarajevo 2013.

Karst retentions and nival factors affect the minor variations in the distribution of rainfall and water levels, as is the case with the April maximum, which is the result of intensive snow melting in the mountains of medium height up to 2000 m. The December maximum occurs due to higher amounts of rainfall during November and December, but the karst retention of high water that runs off into streams after the charge of underground karst recipients. The August and September's minimum occurs due to high evaporation and small precipitation during July, August and September but the impoverishment of aquifers fed streams.

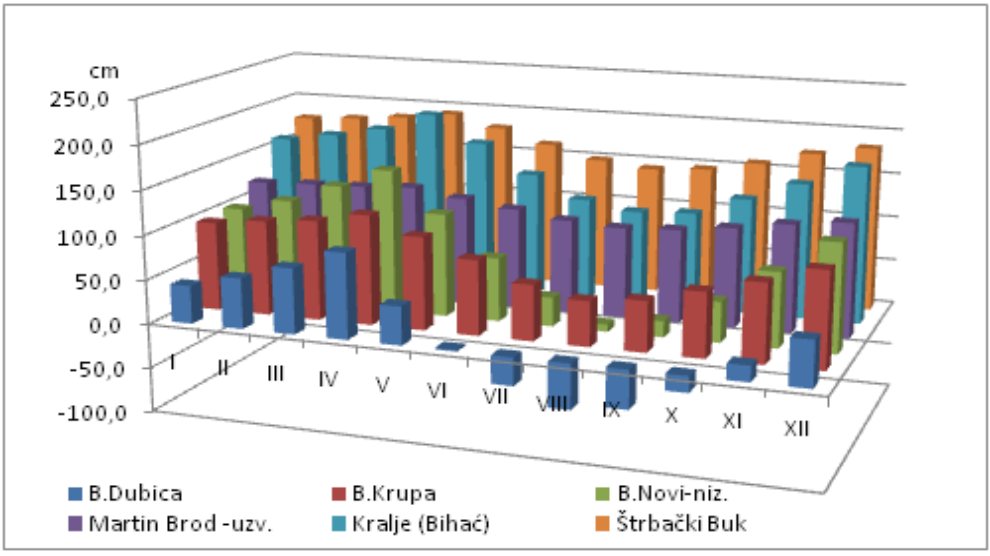

Fig. 1. Graph of the average annual course in water level on the Una

In any case, we can consider two specific period - a period of extremely low water levels (from June to October) and the period of increased water levels (from November to May). Period of low water levels is generally continuous, while in the second period there

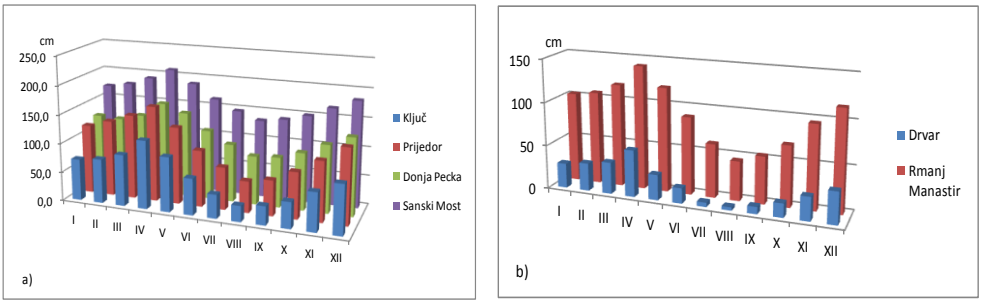

Fig. 2. Graphs of the average annual course of water level on: a) Sana b) Unac

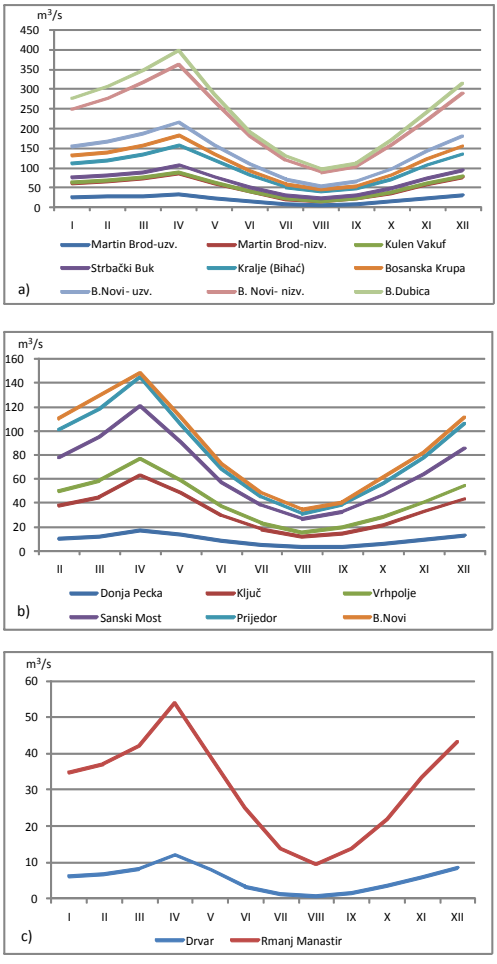

Fig. 3. Graph of the average annual course of the flow on: a) Una b) Sana c) Unac

are certain deviations. In the period of increased water levels markedly winter months, January and February, have a slightly lower water levels as a result of the impact of nival factors, primarily the general hibernation in the highest parts of the basin. Deviations water level of the average values at Una are significant. According to Spahic, M. (1991), the height of the amplitude of the individual water meters were caused by, mainly, the morphometric characteristics of the riverbed, character valley bottom, and the position of tufa cascades, which can be seen at the following attached.

The level of water, hasn't continuous increase or decrease in downstream with the flow of the Una, but depends on a number of factors already mentioned. Almost the same level of water level regime have tributaries of the Una, Sana and Unac. All the characteristics of an annual series of water levels are identical on both rivers, except the already mentioned the lowest levels recorded in Drvar.

There are two main specific period - a period of extremely low water levels (from June to October) and the period of increased water levels (from November to May). The water flow is closely related with the water level, but not its immediate function. Schedule of runoff during the year is conditioned by the amount and distribution of rainfall but also by evaporation, which is

due to the high temperature of the air a lot, so the higher flows at lower rainfall in the spring, but at a higher amount of rainfall that is excreted during the first half of the summer season. The highest flows in April and March, while the secondary maximum is in December, as it is with the water level.

Large amounts of water in the flows in this catchment area during the spring months originate a series of factors: higher precipitation, snow melt in higher hypsometric levels and high saturation of soil moisture which is directly related to increased runoff coefficient of spring water. The lowest flows occurring in August and September. The average annual flows are increasing downstream by hydrological profiles, on all flows in the basin. Certain characteristics of river regimes on the basis of data daily flow are presented in hydrograph of flow. Area limited curve line of hydrograph and coordinate axes corresponds to the volume of water which has flowed through a specific profile. As a representative for the purposes of this paper, was made hydrograph according to data from watermeters in Bosanska Dubica, which represents the total amount ground and surface waters that have passed Una with the entire basin.

The water flow consists of surface and ground water, which come into the river pouring over the soil and seepage through the sides and bottom of the riverbed. The participation of groundwater on hydrograph seems stable flow, while surface waters form variable part of flow. Fluctuations in flow is observed on the hydrograph, is nothing but the average balance increased rhythms and reduced flow. Parsing of hydrograph allows you to set up approximately participation quantity of surface and ground water in flow.

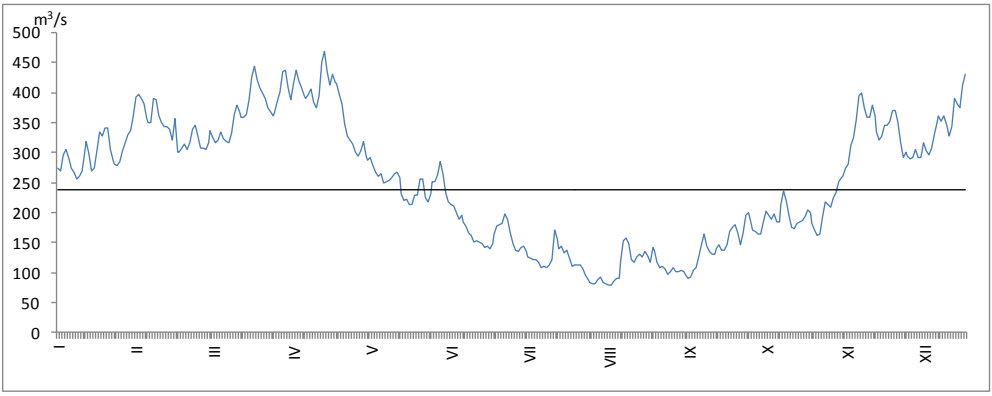

Fig. 4. The hydrograph of average daily flows at Uni (WM Bosanska Dubica, 1961st to 1990th)

According of flow hydrograph, obtained the participation of surface water in flow Una which is 60,8%, while the percentage of groundwater 39,2%. The water flow is very closely related to the water level, if the decline of the riverbed was constant, flow of would be a function of the water level. The dependence of water level - flow of can be represented in many ways, and in potamological research is used curve of flow. Curve of flow may change over time, because it changes the river bed, or changing conditions and regime runoff, especially after the passage of flood waves, which can be seen at the following attached (Fig. 5). Measurements of flow on the river, it is difficult to perform at high water levels, and the volume of flow curve constructed on the basis of measurements, often exceeded

during the arrival of the flood waves. For this reason, the curve is extended, on the above, for high water levels and down, for low water levels.

Tab. 3. Percentage share surface water and groundwater in flow of Una in Bosanska Dubica

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
surfacewater	**77,5**	**70,2**	**74,3**	**65,7**	**75,4**	**71,8**	**36,0**	**30,0**	**60,0**	**63,6**	**28,0**	**78,0**
groundwater	**22,5**	**29,8**	**25,7**	**34,3**	**24,6**	**28,2**	**64,0**	**70,0**	**40,0**	**36,4**	**72,0**	**22,0**

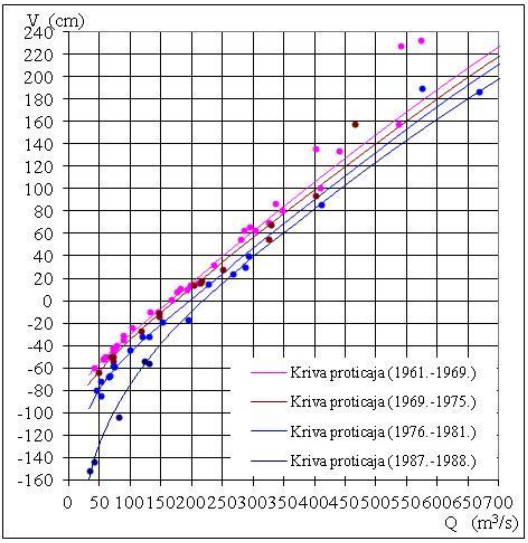

Fig. 5. The curve of the flow in amplitude hydrological measurements, WM Bosanska Dubica

In view of the catchment area and its different natural characteristics caused by mutual relationship of physical geographic factors, was analyzed and especially important hydrological parameter - runoff (inflow). More detailed conclusions about the regime of the Una River can be derived from indicators of runoff values, such as specific runoff, the height runoff and runoff coefficient. Runoff represents the quantity of precipitation waters that comes to water streams within a certain time period. On schedule categories of runoff has great influence geological structure, orographic assembly, energy relief and morphometric characteristics of the basin. Due to this, runoff is different from one to another profile in the basin, which is especially evident when analyzing the height zonation and catchment area upstream of the individual profiles. The specific runoff is a very important unit in the hydrological study of river. The value of specific runoff as a rule reduced from the source to the mouth, and with decreasing the amount of precipitation decreases and the value of specific runoff. This fact is confirmed by the values of specific runoff in the upper part of the river Una, in Martin Brod (downstream) 35,4 liters per sec/km^2, and not far from the mouth, in Bosanska Dubica 24,1 liters per sec/km^2. According to annual series, specific runoff is in line with the increase and decrease in of flow, so we can say that the maximum values of specific runoff recorded in April and December, and the minimum in August.

Specific runoff is also used to calculate the height of runoff, which is nothing more than an average amount of precipitation equally distributed over the basin in a given time, that feeds the flow of. Height of runoff is to some extent proportional to the amount of rainfall, but not completely, because depends on other physical geographic factors regime. So it for Una, in Dubica amounts 759,1 mm annually, while the average value for the entire basin is much smaller and amounts 217,8 mm. If one analyzes the height of runoff to rainfall and evaporation, then it for the basin amounts 606 mm. Also, the values are different when it comes to separate basins by Unac and Sana. The coefficient of runoff resulting from the

relationship height of runoff and the amount of rainfall, and are generally analyzed as an average for the period more year, while the value of this coefficient for a short time taken conditionally, because such a flow of, depending on the rainfall of the previous period. The coefficient of runoff may be different on the same river, depending on relief conditions prevailing in the basin area to a certain hydrological profile. So, in an area with higher slopes, mostly hilly and mountainous, surface flow of rainfall to water streams is not long, evaporation time is shorter and the coefficient of runoff higher. In plain areas, runoff precipitation is longer, higher evaporation and the value of the coefficient is lower. The coefficient of runoff on the river Una, calculating according to height of runoff for the entire basin, is 53%, while this value of the individual hydrological profiles significantly different.

Tab. 4. Comparative data: temperature (T), precipitation (H), water level (V), flow of (Q), specific runoff (q), the height of runoff (y), runoff coefficient (C), the specific intensity of rainfall (i) in the Una to the watermeter in Bosanska Dubica (1961st to 1990th)

B. Dubica	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	God.
T (°C)	-1,7	0,8	5,4	11	15	19	20	19	16	11	6,2	0,9	10,2
H (mm)	64	60	58	79	89	106	86	80	68	67	94	95	946
V (cm)	42,7	56,7	73,4	96	43	1,7	-31	-50	-43	-18	17	50	42,7
Q (m^3/s)	276	306	346	396	286	191	129	97	111	169	241	314	238
q($lsec/km^2$)	27,9	31,0	35,0	40	29	19	13	10	11	17	24	32	24,1
y (mm)	75,3	77,5	94,5	104	78	50	36	27	30	46	63	86	759
C (%)	116	128	161,5	130,6	86,7	46,9	40,5	32,7	42,5	68,1	66,7	89,6	80,2
i($lsec/km^2$)	23,7	24	21,5	30,4	32,9	40,8	31,8	29,6	26,2	24,8	36,2	35,2	30,03

Water balance of the Una River

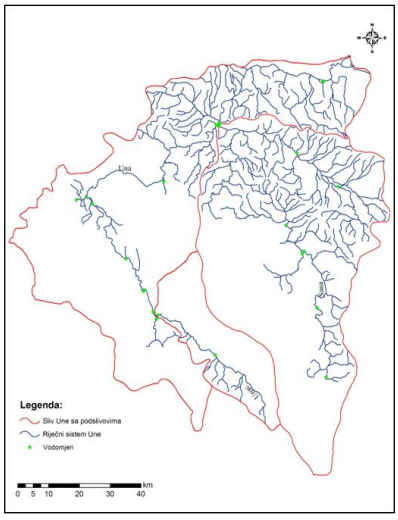

Fig. 6. The basin of Una with sub-basins by Unac and Sana

The need of rational use of water requires a better knowledge of this resource. It contributes to the analysis of the water balance of the basin. Water balance presents a complex equation, from which for many years, which includes the low water and a lot of water years, the equation simplifies and gets the following form X = Y + Z, ie. the total amount of precipitation is equal to the sum of height of runoff and evaporation. For all elements of the water balance are given the average data for the whole river basin, including the smaller streams, which is to some extent reduced the value of all elements of the mainstream. Water balance of certain parts of this area is different, especially when you are isolated sub-basins by Unac and Sana. Elements of water balance, precipitation, evaporation and runoff, have different spatial distribution and the conditions of their formation, which directly affects the condition of the water balance, when you take into account the

lower parts of the basin. Relief, especially altitude and slope, karst, pluviometric and river regime, vegetation but also density of the river network, are important factors in the water balance. Data for the height of runoff, in Table 5, were obtained on the basis of average values of flow, and then the specific runoff from the existing water meters to the flows of the Una, Sana and Unac. Differences in runoff of rainfall per sub-basins, resulting primarily from a karstic terrain characteristics in catchment basin Una and Unac, compared to the catchment area of Sana where dominated hydrological isolators from Paleozoic. Runoff of rainfall in the karst area is mostly underground, and therefore evaporation is less. Water precipitation on the surface appears as a strong, generous karst springs and so directly participate in the runoff values. Lower altitude in the basin of Sana, spacious basin, lower rainfall and slightly higher average annual air temperature, influenced the slow runoff and increased evaporation.

Tab. 5. Water balance of on the catchment area of Una and its sub-basins: X-precipitation, Z-evaporation, Y-height of runoff , C-coefficient of runoff

	Immediate catchment of Una	Unac	Sana	River Una basin
X (mm)	1110,4	1286,4	1060	1147
Z (mm)	375,1	658,4	674,97	541
Y (mm)	735,3	628,04	385,03	606
C (%)	66	49	36	53

Tab. 6. General hydrological parameters in Una river basin (1961st to 1990th): Q-average annual flow off (m^3/s), q-specific runoff (l /s/ km^2), Pef-effective rainfall in mm (height of runoff), P-annual precipitation (mm), C- coefficient of runoff (%)

Water meter	waterstream	altitude (m)	Q	q	Pef (Y)	P	C
Martin Brod -up.*	Una	362,48	20,4	34,6	1091,9	1457,2	74,9
Martin Brod -down.	Una	309,93	51,6	33,3	1050,9	1432	73,4
Kulen Vakuf	Una	298,81	53,2	29,2	921,6	1151	80,1
Strbački Buk*	Una	293,17	65	27,6	871,1	1148,3	75,8
Kralje (Bihać)	Una	208,85	97,6	27,8	877,4	1308	67,1
Bosanska Krupa	Una	149,98	113	27,9	880,5	1192	73,9
B.Novi - up.	Una	116,06	133	30,5	962,6	1020	94,4
B. Novi - down.	Una	116,06	218	25,02	789,6	1020	77,4
B.Dubica	Una	94,17	238	24,4	770,1	946	81,4
Klokot*	Klokot	209,8	15,1	40,7	1284,5	1308,5	98,2
Drvar	Unac	463,51	5,43	11,7	369,2	1108	33,3
Rmanj Manastir*	Unac	314,66	30,5	33,7	1063,6	1434,3	74,1
Donja Pecka*	Sana	401,32	9,26	20,1	634,3	1154,1	54,9
Ključ	Sana	246,93	33,2	29,6	934,2	1080	86,5
Vrhpolje*	Sana	178,24	42,1	31,2	984,7	1047,1	91,1
Sanski Most	Sana	156,18	66,7	26,5	836,3	1023	81,7
Prijedor	Sana	129,68	81,4	21,9	691,2	927	74,6
B.Novi	Sana	116,26	86,6	19,9	628,04	1020	61,6
Hrustovo	Sanica	200	14,7	20,8	656,4	1047,6	62,6
Omarska	Gomjenica	147,66	5,44	14,9	470,2	935,6	50,3

** precipitation obtained on the basis of the average change of quantity with an increase in altitude (47,7mm/100 m)*

An important factor of the water balance is pluviometric regime. It is observed that, the areas that have changed maritime pluviometric regime, have a greater height of runoff as it

is in the southern and southwestern part of the basin of Una. Over this area is a large rainfall appear in the colder period of the year, and snowy and karst retentions contribute less evaporation and increasing runoff. In contrast to this part, basin of Sana has a dominant continental pluviometric regime, where a large part of rainfall appear in the warmer part of the year and mostly evaporates and a smaller part goes to the mainstream. In processing the regime of water levels, of flow and runoff are evident incompliance when it comes to analyzing the hydrological profile positioned at different height zones. On the overall basin of Una, according to meteorological monitoring, an annual average is excreted 11,5 billion m^3 of rainfall. From this amount, the calculation of actual evapotranspiration and infiltration in the basin, it was concluded that in Una annually comes to 6,1 billion m^3 of rainfall, while the 5,4 billion lost in the underground water and the evapotranspiration.

CONCLUSION

River regime of Una and its tributaries has combined pluvio-nival regime different variants, which is a direct consequence of the different climatic conditions, relief, geological structure and vegetation in the basin. At all streams the river system Una, we can single out two specific period - the period of extremely low water levels (from June to October) and the period of increased water levels (November to May). The level of water, there isn't a continuous increase or decrease downstream with the flow of Una, but depends on a number of physical geographic factors.

Schedule runoff during the year is conditioned by the amount and distribution of rainfall and evaporation, which is due to the high temperature of the air a lot, so the higher flows at lower rainfall in the spring, but at a higher amount of rainfall that is excreted during the first half of the summer season. The share of surface water in flow of Una is around 61%, while the percentage of groundwater 39%.

By analyzing the monitoring of existing water meters, over a 30-year period, provided information about the values of the components of the water balance, which for the basin of Una are: Pav = 1147 mm, Y = 606 mm, Z = 541 and C = 53%.

According to these data, on the total catchment area of Una, an annual average is excreted 11,5 billion m^3 of precipitation, of which, the calculation of actual evapotranspiration and infiltration in the basin, in Una annual flows of 6,1 billion m^3 of precipitation, while 5,4 billion water loses. If we take into account only evapotranspiration, which for the basin Una is 415,6 mm, obtained by the total amount of water flowing into the river Una, 7,3 billion m^3.

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