

Rainfall Influence On Irrigation Water Consumption In Strezevo Irrigation System

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Abstract

In this paper will be explored the influence of the rainfalls with different durations and intensities on irrigation water consumption of some main irrigation pipelines of Strezevo Irrigation System during the watering season.

For this research, hourly records of rainfalls from Bitola Meteorological Station and respectively hourly records of irrigation water consumption of few neighbouring main irrigation pipelines of Strezevo Irrigation System are available for a period of 12 years.

From this research is also expected to confirm some opinions about farmers' bad irrigation practices in Strezevo Irrigation System.

Keywords: rainfalls, irrigation water consumption.

General data

The Strezevo Irrigation System is situated in the south-western part of the Republic of Macedonia. It is multipurpose system which obtains irrigation of 20.200 ha net cultivated area and domestic and industrial water supply.

The climate could be defined as semiarid, moderate hot with 4 - 5 arid months and with 2 - 3 hot months. The hottest months are July and August with mean temperature of 22.2 °C and 21.7 °C, respectively. As an annual mean there are 97 summer days (days with maximal temperature higher than 25 °C) and 34 tropic days (temperature higher than 30 °C). The mean annual precipitations are 614 mm, with wide variations between 426 mm (in 1993) to 852 mm (in 1981). The amount of mean annual precipitations in vegetation period (April-September) is 265 mm. The droughts are frequent phenomena through the whole year, especially in summer season. The years from 1987 to 1993, are most driest ones for last hundred years.

Rainfalls influence on irrigation water consumption

Studying on rainfall influence on water consumption for irrigation is of a great importance for the daily control of water running through transportation and distribution structures of the system "Strezevo". The small reserves for surplus water storage behind the regulation structures of the Main Supply Canal and its two compensation basins (cca 45000 m³), non functionality of the greater part of the safety overflow along the canal in combination with transportation delay, which occur because of great canal length and sudden stoppage of irrigation because of raining, are the reasons, which make the system "Strezevo" particularly sensible on this natural phenomenon.

When gets cloudy, and which may result in rain, the water dispatcher in System's Command Center has to take some steps which would prepare the system to face with eventual heavy rain and expected decrease of irrigation water consumption. As a first step is quick and adequate decrease of released water by the reservoir "Strezevo", having into consideration the fact that because of transportation delay will pass at least 6 hours until this decrease reach the first consumer - main irrigation pipeline with its lateral distributive network. A second preventive step is to increase water storage reserves along the Main Supply Canal through re-distribution of water in the more faraway canal sections and its consumption or letting out into the recipient. During these operations the risk of electric power failure because of bad weather (thunderstorm, strong wind and etc.) is always present, and if it is case, the water dispatcher cannot obtain remote manipulation with regulation equipment. In such cases is spent time for timely reaction because working group which is on duty should go to the certain regulation structure by a vehicle and to make the operation on manual drive.

If is reacted inadequately and not on time it may result in over-filling and overflow of the water out of Main Supply Canal and flooding of the land under it, resulting in big material and financial damages.

Rain analysis

In the paper will be analyzed the influence of rains in the vegetation period on water irrigation consumption during the watering seasons from 1990 to 2002, with available records about the precipitations by the Meteorological Station of Bitola, registered by pluviograph (see a Table 1).

The application of irrigation in the System "Strezevo" is necessary due to insufficient rainfalls quantity and their unequal distribution during the year, with emphasized deficit in the peak irrigation season (July and August).

Table 1. Bitola Meteorological Station - Monthly sums of rainfalls in vegetation season (April - September) in [mm]

	IV	V	VI	VII	VIII	IX	Sum IV-IX
1990	42.7	37.4	9.0	38.9	46.2	37.6	211.8
1991	101.9	88.7	8.0	61.1	97.8	68.7	426.2
1992	131.8	47.8	85.8	22.0	16.2	2.4	306.0
1993	96.4	54.1	39.1	6.3	16.0	10.1	222.0
1994	96.7	13.1	32.2	41.2	48.2	5.9	237.3
1995	30.1	88.5	10.3	73.1	49.5	50.2	301.7
1996	22.5	71.6	15.1	30.0	48.5	111.8	299.5
1997	50.6	27.2	14.8	27.9	43.9	11.0	175.4
1998	21.3	82.1	22.3	23.9	22.2	67.4	239.2
1999	33.7	14.2	91.0	52.1	9.0	52.1	252.1
2000	26.6	31.6	14.4	8.9	4.3	19.6	105.4
2001	90.7	50.9	12.9	10.5	29.9	16.0	210.9
2002	64.7	129.8	9.5	84.9	35.0	125.5	449.4
Average	62.3	56.7	28.0	37.0	35.9	44.5	264.4

In Table 2 is given a review for the days with rain during the period 1990 - 2002. The data are taken by the Meteorological Station in Bitola, which is located in the center of the Strezevo Irrigation System.

By the review can be noticed that are low rainy days, as well as the mean monthly sum of rainfalls.

Table 2. Number of rainy days (>0.1 mm per day) in the vegetation period (April-September) during the watering seasons 1990 - 2002

	IV	V	VI	VII	VIII	IX	Sum
1990	16	10	7	4	5	5	47
1991	21	15	6	13	7	6	68
1992	11	11	12	7	2	5	48
1993	17	13	4	1	3	5	43
1994	18	8	9	11	5	3	54
1995	8	17	4	10	13	11	63
1996	12	10	3	4	4	15	48
1997	12	5	3	5	9	1	35
1998	8	18	5	4	4	11	50
1999	12	9	13	12	4	13	63
2000	12	8	7	3	3	4	37
2001	15	10	5	4	7	5	46
2002	14	16	5	12	10	19	76
Average	13.5	11.5	6.4	6.9	5.8	7.9	52.2

From practical reasons, a distribution of the rainfalls was made according to Hoppe's criteria (Milosavlevic, 1976) in sense of their intensity in the following classes: low rains - with height of precipitation up to 1 mm per day, moderate rains from 1.1 to 5 mm per day, heavy rains from 5.1 to 10 mm per day and very heavy rains over 10 mm per day. According to these criteria, the total number of rainy days presented in Table 2 is distributed per classes for each month in the irrigation season separately, and in Table 3 is presented the summary about the whole considered period.

Table 3. Number of days with characterized rainfalls in vegetation season (April - September) and their percentage participation in the number of all rainy days

	All	Low rain	Moderate rain	Heavy rain	Very heavy rain	Low rain	Moderate rain	Heavy rain	Very heavy rain
	(1)	(2)	(3)	(4)	(5)	(2)/(1) [%]	(3)/(1) [%]	(4)/(1) [%]	(5)/(1) [%]
1990	47	21	12	8	6	44.7	25.5	17.0	12.8
1991	68	24	27	3	14	35.3	39.7	4.4	20.6
1992	48	19	11	6	12	39.6	22.9	12.5	25.0
1993	43	14	17	6	6	32.6	39.5	14.0	14.0
1994	54	22	19	8	5	40.7	35.2	14.8	9.3
1995	63	21	27	7	8	33.3	42.9	11.1	12.7
1996	48	12	21	5	10	25.0	43.8	10.4	20.8
1997	35	10	12	7	6	28.6	34.3	20.0	17.1
1998	50	18	15	8	9	36.0	30.0	16.0	18.0
1999	63	26	24	5	8	41.3	38.1	7.9	12.7
2000	37	16	15	5	1	43.2	40.5	13.5	2.7
2001	46	19	16	3	8	41.3	34.8	6.5	17.4
2002	76	21	30	13	12	27.6	39.5	17.1	15.8
Average	52.2	18.7	18.9	6.5	8.1	36.1	35.9	12.7	15.3

For the considered period (1990 to 2002) from the total number of days with rainfalls with nearly same frequency are the low rainfalls class (36.1%) and the moderate rainfalls class (35.9%). Very heavy rains (15.3%) are little more frequent than the heavy rainfalls (12.7%).

The rainfall influence will be estimated according to the extent in decrease of water consumption for irrigation for the current day and days following on.

During the vegetation period of the plants were considered the rainfalls from April to September inclusive.

We shall consider separately the influence of all rain classes, by months during period 1990-2002.

April

According to Table 2, April is a month with greatest number of days with rainfalls, the average for the specified period is 13.5 days. From this number, in average, 6.0 days are with low rain, 4.2 days are with moderate rain, 1.6 days with heavy and 1.7 days with very heavy rain.

In this month, in a half of years in considered period (1991, 1992, 1996, 1997, 2000, 2001 and 2002) the irrigation system is not put in a function due to sufficient quantity of moisture in the soil. In the other years (1993, 1998, 1999) in the last third of the month, started filling of the pipeline irrigation network, which because of protection against freezing, after completion of the former irrigation season is being emptied.

In the years, when there is an irrigation during whole month (1990, 1994), it is with average daily water flows between 100 and 1500 l/s, and the average for the period is 250 l/s.

The low and moderate rainfalls do not have significant influence upon decrease of consumption, while the heavy and very heavy rains result in suspend of irrigation of couple of days.

A rainfall of 10.6 mm on April 9, 1990 caused a decrease of the average daily flow water of 661 l/s to 165 l/s, that is a decrease of 4 times and the same ratio of decrease is retained also in the next day when a rainfall of 9.8 mm caused decrease of the average daily flow from 165 l/s to 43 l/s.

We have also nearly identical decrease in much more intensive rainfall of 49.7 mm (22.04.1994), so that the average daily flow of 586 l/s decreased to 131 l/s, and a rainfall of 9.8 mm (23.04.1994) caused a decrease of the average daily flow water of 131 l/s to 40 l/s.

Such enormous decreases in water consumption are possible at the beginning of the irrigation season, when the water flow for irrigation is relatively small.

May

According to Table 2, May is a second month in the vegetation period per number of days with rain, the average for the specified period is 11.5 days. From this number, in average, 3.5 days are with low rain, 5.1 days are with moderate rain, 1.3 days are with heavy and 1.6 days with very heavy rain.

In this month, there was no irrigation in 1991, 2001 and 2002. In the other years, there was irrigation with average daily water flows between 300 and 3000 l/s, while the average for the period is 942 l/s.

May 1993 was a rainy month, but because of low irrigation, the rainfalls had not any great influence on decrease of consumption. Nearly the same situation was in 1994. There was a poor irrigation in May 1995, moderate rainfalls of 2 mm and more have no significant influence on consumption. In 1997, May had low rainfalls, without significant influence on irrigation water consumption. There were low rainfalls in May 1999 with a small influence, and sometimes with increase in consumption after a rainy day. In addition, in 2000 there was a filling of the irrigation network and low rainfalls.

On 13.05.1990, a very heavy rain (12.7 mm) caused a decrease of consumption from 2548 l/s to 1091 l/s (57%). The following day, a rainfall of 3 mm caused a decrease in consumption from 1091 l/s to 631 l/s (42%), it was on the same level the following day without a rain (675 l/s), before starting increase.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
13-05-1990	12.7	18	15	2548		
14-05-1990	3.0	8	0	1091	-1457	-57
15-05-1990				631	-460	-42
16-05-1990				637	6	1

The marks used in this table and those that will follow have the following meaning:

- P [mm] - height of precipitation in mm, measured for the current day from 0-24 h with pluviograph in the Meteorological Station in Bitola
[h] [min] - time duration of rainfall expressed in hours and minutes
Q [l/s] - mean daily irrigation water flow at total irrigation network level in l/s
D [l/s] - difference between mean daily irrigation water flows of the current and previous day in l/s.
D [%] - percentage of decrease of mean irrigation daily water flows of the current and previous day in %.

On 27.05.1990 a moderate rainfall of 2.8 mm, caused a decrease in consumption from 2916 to 2687 l/s, (8%). On 29.05.1990 very heavy rainfall of 11.4 mm, caused a decrease from 2687 to 1923 (28%) and a decrease for following day without a rain to 1516 l/s (21%).

Between 21 and 22 May there was a very heavy rain of 18.4 mm with slightly decrease in consumption (2%), and between 22 and 23 May with a heavy rainfall of 5 mm, there was increase in consumption of 13%.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
21-05-1995	18.4	8	50	485		
22-05-1995	5.0	6	45	473	-12	-2
23-04-1995	1.3			536	63	13

On 11.05.1996 very heavy rainfall with thunderstorm caused electric power failure in the Repetitor Station which covers all System's area and is responsible for teletransmission of data from all measurement points. Because of that, there were no possibilities to control and made any changes in transportation and distribution of water from the System's Command Center. Although it was pouring rain, the rainfall caused only 7% decrease in consumption. In the days followed on afterwards, there was a series of moderate and low rainfalls, with slightly influence on consumption, and also were registered its increases.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
11-05-1996	39.4	9	55	293		
12-05-1996	1.9	1	15	272	-21	-7
13-05-1996	5.5	2	55	370	98	36
14-05-1996	0.1	0	25	322	-48	-13
15-05-1996	2.4	1	40	317	-5	-2
16-05-1996				323	6	2

In 1998, in a series of eight rainy days of 03.10 - 10.05 with poor and moderate rainfall, there was a continuous increase of the consumption for irrigation water. It is because at the beginning of the month started filling of the pipeline network, including new section pipelines for irrigation, and according to rough estimate, the small consumption increased.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
03-05-1998	2.4	4	20	904		
04-05-1998	0.3	0	40	856	-48	-5
05-05-1998	1.2	3	0	1365	509	59
06-05-1998	1.4	4	15	1508	143	10
07-05-1998	2.9	5	10	1419	-89	-6
08-05-1998	1.0	0	30	1755	336	24
09-05-1998	0.9	3	40	1924	169	10
10-05-1998	2.8	7	30	1426	-498	-26

In the Table below is presented a new series of pouring rainfalls of 16.05 - 21.05 with "inadequate" decrease of the consumption.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
15-05-1998				1414		
16-05-1998	17.6	15	55	993	-421	-30
17-05-1998	2.1	2	10	649	-344	-35
18-05-1998	10.7	7	50	727	78	12
19-05-1998	9.2	6	5	804	77	11
20-05-1998				694	-110	-14
21-05-1998	0.2	0	30	521	-173	-25

The small rainfall influence in the month of May is because of the fact that there is a filling of irrigation network, with every day inclusion of numerous section pipelines in consumption and of relatively small, starting consumption of irrigation water.

June

According to Table 2, June in the vegetation period has in average 6.4 days with rain, which is the second lowest value. From this number, in average, 2.7 days are with low rain, 2.0 days are with moderate rain, 0.8 days with heavy and 0.9 days with very heavy rain.

In the second half of June can be noticed a significant increase in water quantity for irrigation. The irrigation is intensive with average daily water flows between 1000 and 5500 l/s, and the average for the period is 2074 l/s.

There was a poor irrigation in this month during the 1992 and 2001, while in 2002 there was no irrigation because of water deficit. 2001 is also a year with a deficit, when from 10 main pipelines which comprise the irrigation network, in a function are only two, through which are supplied a limited number of agricultural areas by the public sector.

On 16.06.1990 a rainfall in height of 6.8 mm followed by a thunderstorm caused 40 hours interruption in irrigation - the main pipelines were shut off.

In the Table below is given the influence on rainy period from 16.06 - 18.06.1992 with very heavy rainfalls, when the trend on consumption decrease continued on the following two days without a rain, and in the third day to be retained the previous consumption. There was water surplus in all days of decrease consumption, which are let out in the recipients through two sided overflows of the Main Supply Canal.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
16.06.1992	30.3	4	0	763		
17.06.1992	15.7	5	30	282	-481	-63
18.06.1992	14.6	1	0	161	-121	-43
19.06.1992				68	-93	-58
20.06.1992				35	-33	-49
21.06.1992				36	1	3

June 1998 was very poor in rainfalls. A very heavy rainfall on 09.06.1998 caused a small decrease (9%) in consumption, which was because of the poor irrigation in that month.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
09-06-1998	12.4	0	55	803		
10-06-1998				728	-75	-9

On June 1999, a rainy period from 12.06 and 23.06 is a mixture from very heavy, heavy, moderate and poor rainfalls, which resulted in total decrease of the average daily water consumption for irrigation of about 3000 l/s. From 17.06 - 18.06 in addition the strong rainfall, the irrigation increased to 5%.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
11-06-1999				4123		
12-06-1999	35.5	2	20	3953	-170	-4
13-06-1999	0.5	0	10	3016	-937	-24
14-06-1999				2979	-37	-1
15-06-1999	3.2	2	32	3009	30	1
16-06-1999	7.1	1	30	2074	-935	-31
17-06-1999	13.5	6	50	1398	-676	-33
18-06-1999	1.2	0	55	1465	67	5
19-06-1999	14.5	0	25	1154	-311	-21
20-06-1999	0.5	0	35	1009	-145	-13
21-06-1999	8.9	2	57	1034	25	2
22-06-1999	1.2	1	40	1212	178	17
23-06-1999				1370	158	13

The running of mean hourly water flows for the irrigation network in the analyzed period is given on graphical presentation on Figure 1. It could be noticed by the diagram that in the days from the second half of the rainy period, when in the soil is accumulated the former moisture, it resulted in straightening of the daily consumption line, which usual form was as well as in the days of the first half of the period, with increase of consumption in noon and afternoon hours.

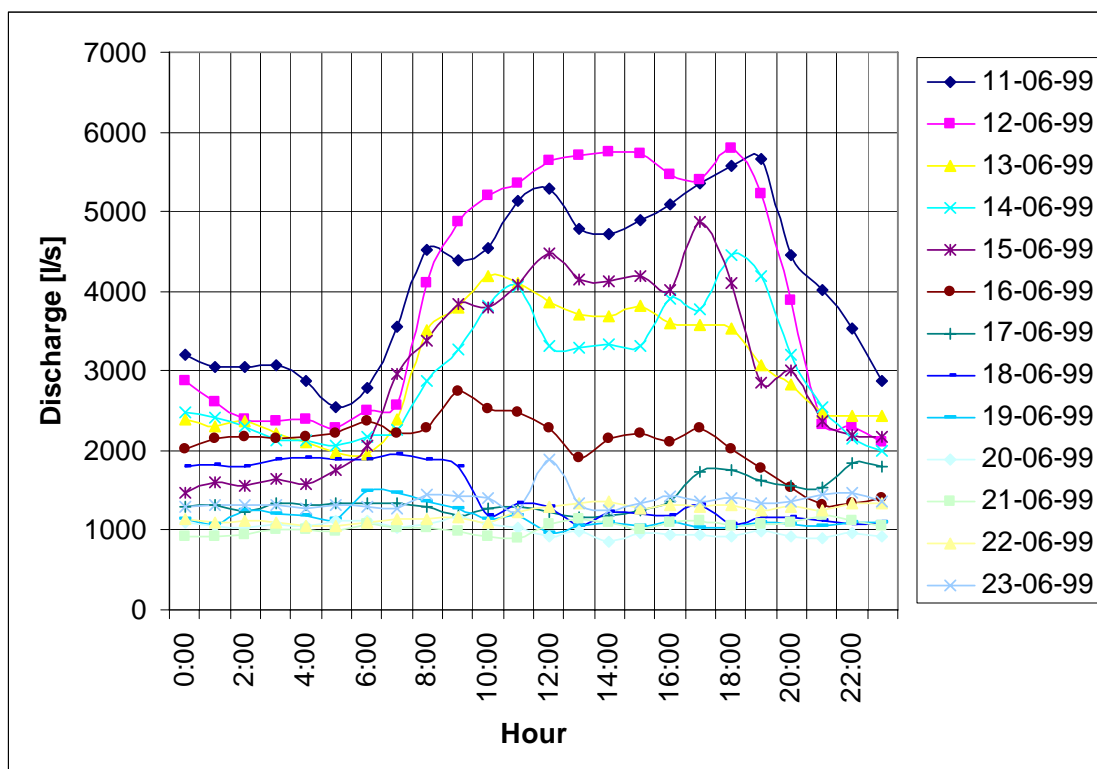


Figure 1. Diagram of hourly irrigation water consumption at total irrigation network level

July

According to Table 2, July has in average 6.9 days with rain. From this number, in average, 2.2 days were with low rain, 2.6 days were with moderate rain, 1.1 days with heavy and 1.0 days with very heavy rain. The irrigation is intensive with average daily water flows between 1500 and 6800 l/s, and the average for the period is 3716 l/s.

On 27.07.1990 the irrigation season was stopped because of the small water level in the Reservoir "Strezevo".

From an event in 1994 it can be seen that, a rain with the same height of rainfalls, at the beginning of the month caused decrease consumption in the following day and resulted in increase in the middle of the month.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
02-07-1994	7.4	0	48	3725		
03-07-1994				2089	-1636	-44
15-07-1994	7.4	1	35	2387		
16-07-1994				2967	580	24

On 18.07.1995 very heavy rain with thunderstorm caused a communication failure in the whole System in time duration of 60 hours. In that period, the Computer Control Center had not received any data for consumed water by the main irrigation pipelines and about the state of water levels along the Main Supply Canal. Because of unknown consumption of the main pipelines and impossibility of water control, occurred regulation water surpluses were let out in the rivers. On July 20, field water masters reported a failure on the main irrigation pipeline 10 C, which in a case of operation of the Control Center could be detected at once.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
18-07-1995	26.6	2	29	3696		
19-07-1995	1.0	1	10	2757	-939	-25
20-07-1995				2577	-180	-7
21-07-1995	2.1	0	36	2068	-509	-20
22-07-1995				1590	-478	-23
23-07-1995				2163	573	36

On 31.07.1995 there was a rainfall with thunderstorm, failure communications in the whole system in duration of 6.5 days. The consequences were as the same as in the previous case.

There was another thunderstorm on 08.07.1998, which caused communications failure in the whole system, in time lasting of 30 hours.

August

August is a month with least rainy days in the vegetation period. According to Table 2, in average 5.8 days were with rain. From this number, in average, 1.9 days were with low rain, 1.8 days were with moderate rain, 0.6 days with heavy and 1.5 days with very heavy rain.

The irrigation is intensive with average daily water flows between 1500 and 6800 l/s, and the average for the period is 3328 l/s.

There was no irrigation in 1990 and 2001. In 2002 there was irrigation only for a part of the public areas.

A pouring rain on 15.08.1991, in height of 50 mm followed by thunderstorm, caused a communication failure in the whole system and release of water on side overflows on the Main Supply Canal. The rainfall influence on water consumption for irrigation was particularly expressed on two main irrigation pipelines: 3C and 4C.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
15-08-1991	50.0	2	1	1606		
16-08-1991				1016	-590	-37
17-08-1991				923	-93	-9
18-08-1991				860	-63	-7
19-08-1991				1606	746	87

The rainfall distribution on 15.08.1991 per hours and intensity is presented in the table given below.

14-15		15-16		16-17		17-18	
mm	min	mm	min	mm	min	mm	min
39.9	56	0.1	10	0.1	10	9.9	45

On the diagrams shown in Figure 2 and Figure 3, is presented the influence on above specified rain on water irrigation consumption for the whole irrigation network and for one main irrigation pipeline (5C). On diagrams for 15.08.1991 might be noticed a rapid water flow decrease after rain beginning at 2:00 p.m. The following three days the consumption water diagram for irrigation is nearly straight line. The water consumption increased in the fourth day. The similarities of diagrams on Figure 2 for the whole irrigation network and Figure 3 for one main irrigation pipeline 5C, which is in vicinity of the Meteorological Station in Bitola, where the rain is registered, indicate that the rain was equally distributed along the entire irrigation area of the Strezevo Irrigation System.

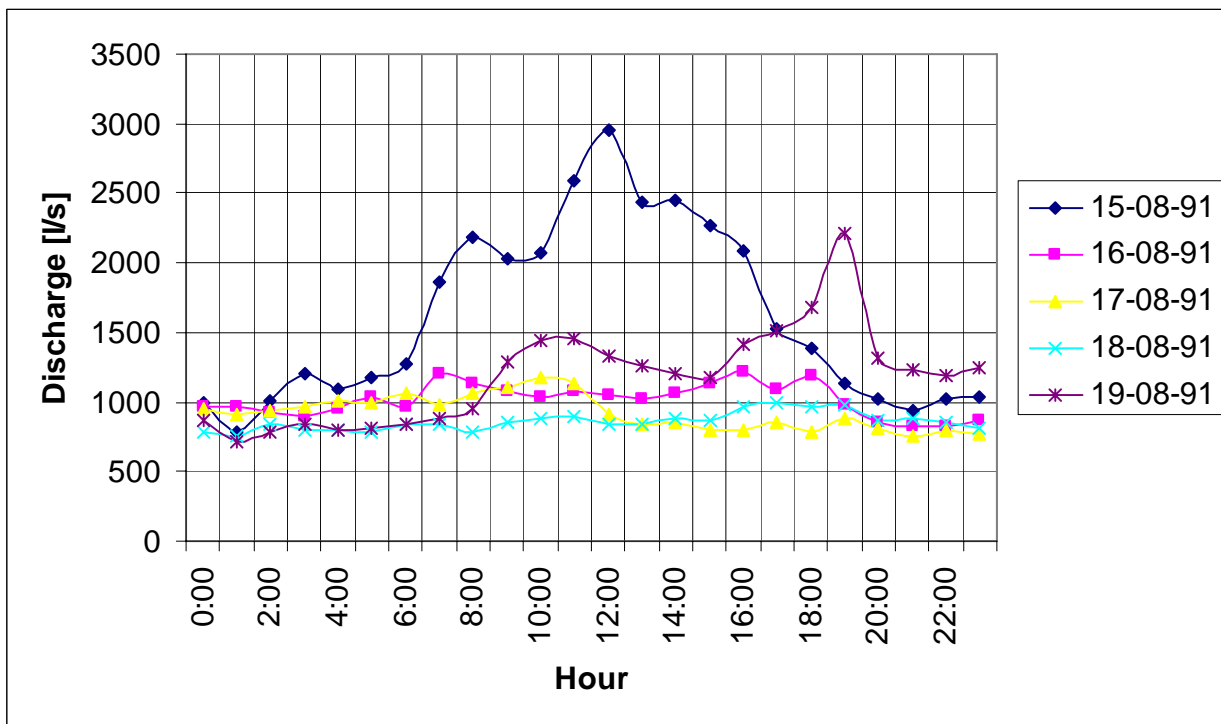


Figure 2. Diagram of hourly irrigation water consumption at total irrigation network level

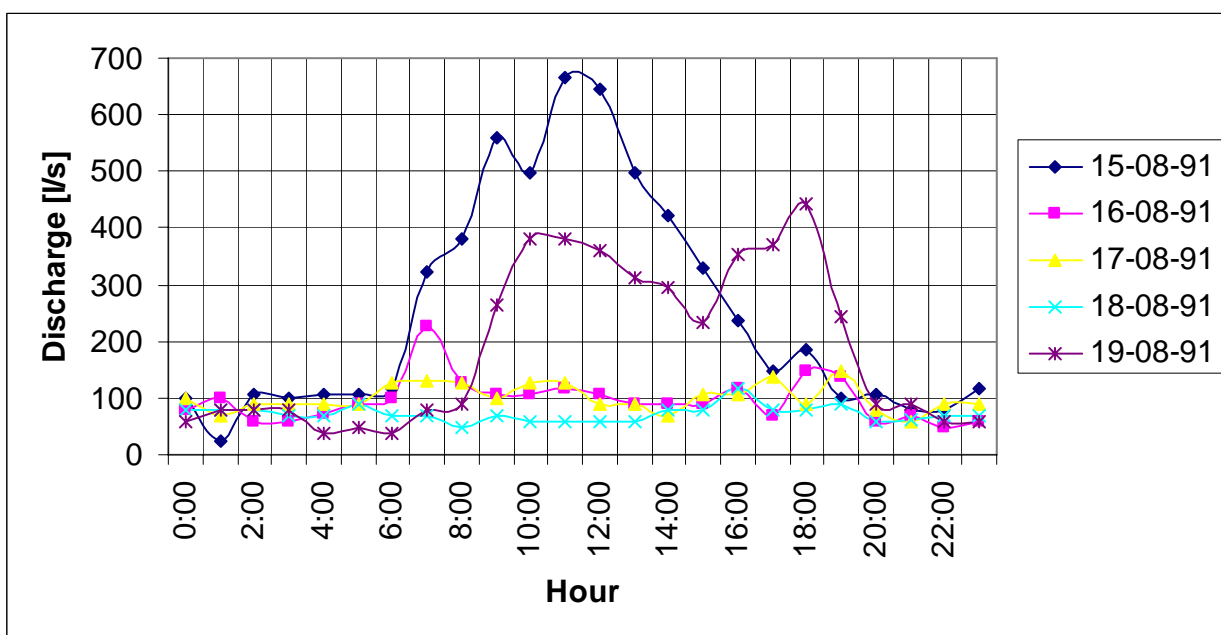


Figure 3. Diagram of hourly irrigation water consumption at main irrigation pipeline 5C

On 16.08.1992 there was a rainfall, followed by thunderstorm (14.4 mm), which caused a failure communication in the whole system, in duration of nearly two days.

The example below is one of the most ones, which indicate that the poor rainfalls have not any influence on water irrigation consumption, where was noticed an increase in water consumption in the following day.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
09-08-1994	1.0	0	50	3308		
10-08-1994				4006	698	21

On 17.08.1995 because of rainfalls in the following days there were periodical communication failures in the Computer Control Center. In these days there were regulation water surpluses emptying into the rivers. Also, there was a failure on the main irrigation pipeline 9C on 21.08.1995.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
14-08-1991				3668		
15-08-1991	3.2	5	30	3368	-300	-8
16-08-1991	0.2	0	30	3042	-326	-10
17-08-1991	15.8	6	40	2170	-872	-29
18-08-1991				1437	-733	-34
19-08-1991				1603	166	12

There was a thunderstorm on 31.08.1995. On 01.09.1995 there was communication failure and failures on the main irrigation pipelines 2C and 9C.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
30-08-1995				1539		
31-08-1995	17.3	10	55	1209	-330	-21
01-09-1995	0.6	0	57	711	-498	-41
02-09-1995				650	-61	-9

In 1995, with thunderstorm rainfalls, during the communication failure occurred failures on main irrigation pipelines on 20.06.1995, 21.08.1995 and 01.09.1995. A main reason for the pipeline failures were water hammers caused by the rapid shutting off the lateral pipelines of the irrigation network.

A rainfalls followed by a thunderstorm on: 29.08.1996 and 16.08.1998 caused communication failure in whole System of 7 hours and a half a day, respectively. In the middle of August, in the former years are also occurred communication failures, caused by rainfalls followed by thunderstorm.

On 28.08.1998 because of the religious holiday - Holy Virgin Mary's Day, there was a decrease of the average water irrigation consumption of 722 l/s due to which occurred release of surplus water on side overflows of Main Supply Canal. A similar effect in decrease of irrigation water consumption also caused the very heavy rainfall on 29.08.1998.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
27-08-1998				3801		
28-08-1998				3079	-722	-19
29-08-1998	10.2	4	20	2670	-409	-13
30-08-1998				1744	-926	-35

September

September (see Table 2) has in average 7.9 rainy days in the vegetation period. From this number, in average, 2.3 days were with low rain, 3.2 days were with moderate rain, 1.0 days with heavy and 1.4 days with very heavy rain.

The irrigation was with average daily water flows between 500 and 3000 l/s, and the average for the period was 1308 l/s.

There was no irrigation in 1990, 2001 and 2002 because insufficient storage water for irrigation in the Reservoir Strezevo. September 1992 was very poor in rainfalls, September 1996 was rainy month, and there was only one rainy day in September 1997.

At the end of September or beginning of October, the watering season usually finishes after pouring rain. That was the case on 26.09.1991, 04.10.1992, 03.10.1993, 29.09.1995, 24.09.1996, 08.10.2000, when after heavy rainfall the irrigation network was closed.

In the table below are shown two cases of rainfall influence on decrease in irrigation water consumption on September.

Date	P [mm]	[h]	[min]	Q [l/s]	D [l/s]	D [%]
17-09-1991	13.1	3	37	1428		
18-09-1991	8.6	0	28	918	-510	-36
19-09-1991	0.3	0	15	821	-97	-11
20-09-1991				692	-129	-16
04-09-1993				2143		
05-09-1993	5.8	3	0	1671	-472	-22
06-09-1993				1334	-337	-20
07-09-1993				1076	-258	-19

Conclusions

From the analysis of rainy days during the vegetation period in the watering seasons 1990 - 2002 and rain influence on irrigation water consumption in the Strezevo Irrigation System can be drawn the conclusions as follows:

The class of poor rainfalls has nearly no practical significance on irrigation during the all months of the vegetation period.

The moderate rains influence on decrease of irrigation water consumption and that influence can be also noticed the following day with no rain.

The heavy and very heavy rainfalls result in irrigation stagnation of couple of days. The class of very heavy rainfalls has a continuous influence on irrigation depending on rainfall depth, because the class is not limited in upper side.

At the beginning of the irrigation season (April, May), pouring rainfall may result in stoppage of irrigation for couple of days, while in September, at the end of irrigation season, this type of rainfall means entirely stoppage of the irrigation and emptying of the irrigation network.

In numerous examples, the heavy rainfalls in the main irrigation season (July - August) are followed by very bad weather (thunderstorm, wind), which are often a reason for occurrence of failures in the electric power supply and in the irrigation pipelines. The failure electric power supply in the Repeater Station or its damaging caused by lightning, result in a radio connection failure through which transmit the measurements of quantities of delivered and consumed water in the Main Supply Canal. It means impossibility for water control during this state.

Additional pressure in such situations is the impossibility of majority of the safety overflow structures on the Main Supply Canal (eight from ten) to release any water surplus caused by heavy rain, without damages on surrounding land.

On the areas of the Strezevo Irrigation System, where furrow irrigation is taking place, is very frequent the bad farmer's practice that after satisfaction of their irrigation water needs, they do not shut off the water on the hydrant, but instead of that, they divert water in the drainage canals and from there it flows in the rivers. This negative practice in the irrigation particularly is in massive usage in a case of unexpected rainfall. Therefore, it occurs that after pouring rainfalls, the water consumption for irrigation is not decreased adequately to rainfall intensity.

References

Kondinski I. 2006. *Water Consumption Forecast and Water Demand Management in Strezevo Irrigation System, BALWOIS Conference on Water observation and Information System for Decision Support, Ohrid, Republic of Macedonia.*

Milosavljevic M. 1976: *Klimatologija. Naucna knjiga, Beograd.*

Vukelic Z, Taseva Jankovic J, Kondinski I. 2005. *Irrigation management transfer in European countries of transition - Macedonian Report. International Workshop in Slubice, Poland.*