HYDRO-ENERGY SUITABILITY OF THE RIVERS REGARDING THEIR HYDROLOGICAL AND HYDROGEOLOGICAL CHARACTERISTICS

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INTRODUCTION

- ENERGY CONSUMPTION IS RAPIDLY GROWING FROM YEAR TO YEAR AND THE PUBLIC AND DECISION MAKERS HAVE REALIZED THE IMPORTANCE OF SWITCHING TO CLEAN AND RENEWABLE ENERGY SOURCES.
- HYDROPOWER PLANTS, INCLUDING SMALL-SCALE HYDROPOWER PLANTS, PRODUCE THE MAJORITY OF THE ENERGY DEEMED AS RENEWABLE.
- UNLIKE LARGE-SCALE HYDROPOWER PLANTS, MINI AND MICRO HYDROPOWER PLANTS, IF CAREFULLY PLANNED AND MANAGED, TEND TO CAUSE NO ENVIRONMENTAL DAMAGE AND CAN BE CONSIDERED PERFECTLY SAFE FOR THE ENVIRONMENT.
- ALSO, MICRO AND MINI HYDROPOWER PLANTS ARE NATURE-FRIENDLY, CHEAPER IN COMPARISON TO LARGE HYDRO POWER PLANTS, AND CAN BE INSTALLED AT ALMOST ANY WATER COURSE.

- SMALL RIVERS AND WATER COURSERS, WITH THEIR CHANGEABLE VELOCITIES AND TORRENTIAL CHARACTERISTICS, CAN POSE A CHALLENGE WHEN PLANNING FOR AN INSTALLATION OF MINI OR MICRO HYDROPOWER PLANTS.
- KEY INPUT PARAMETERS FOR SIZING OF MICRO AND MINI HYDROPOWER PLANTS WILL BE PROVIDED WITH RESEARCH AND ANALYSIS OF HYDROLOGICAL AND HYDROGEOLOGICAL PROPERTIES OF THE RIVERS.
- ONE OF THE BASIC PARAMETERS FOR HYDROPOWER POTENTIAL OF RIVERS ARE DAILY AVERAGE FLOWS.
- IN LIGHT OF THAT, THOROUGH ANALYSIS OF THE TIME SERIES OF AVERAGE DAILY FLOWS OF WATER COURSE WILL BE CARRIED OUT, NOT JUST AS MENTIONED INPUT PARAMETER, BUT ALSO FOR FURTHER ELABORATION OF THE PROJECT.
- OTHER KEY INFORMATION FOR RELIABLE ANALYSIS AND SIZING OF THE HYDROPOWER PLANT MODEL IS HYDROGEOLOGICAL CHARACTERIZATION OF THE MEDIUM UNDERLYING THE RIVERBED.

METHODOLOGY

- FIRST PART IS RESCALED ADJUSTED PARTIAL SUMS (RAPS) METHOD, WHILE THE SECOND PART IS HYDROGEOLOGICAL ANALYSIS OF THE ANALYZED LOCATION, IN ORDER TO OBTAIN THE COMPREHENSIVE VIEW OF THE TOPIC.
- RAPS IS A WELL-KNOWN METHOD BASED ON A VISUAL DETERMINATION OF A SUBSERIES FROM ORIGINAL SERIES OF DATA. BY USING THE AVERAGE VALUE AND STANDARD DEVIATIONS OF THE OBSERVED TIME SERIES, RAPS VALUES PROVIDE INSIGHT INTO THE PARTS, WHERE OCCURRENCE OF THE TRENDS, DATA GROUPING, FLUCTUATIONS AND SIMILAR APPEARANCES DURING THE TIME:

$$RAPS_k = \sum_{t=1}^{k} \frac{Y_t - \overline{Y}}{S_y}$$

- METHODOLOGY PRESENTED IN THE PAPER GIVES RELIABLE PROJECTION OF THE HYDRO-ENERGY POTENTIAL OF ANALYZED LOCATIONS, WHICH COULD BE VERY USEFUL FOR INVESTORS, AS WELL AS FOR THE DESIGNERS OF HYDRO POWER PLANTS.

CASE STUDY

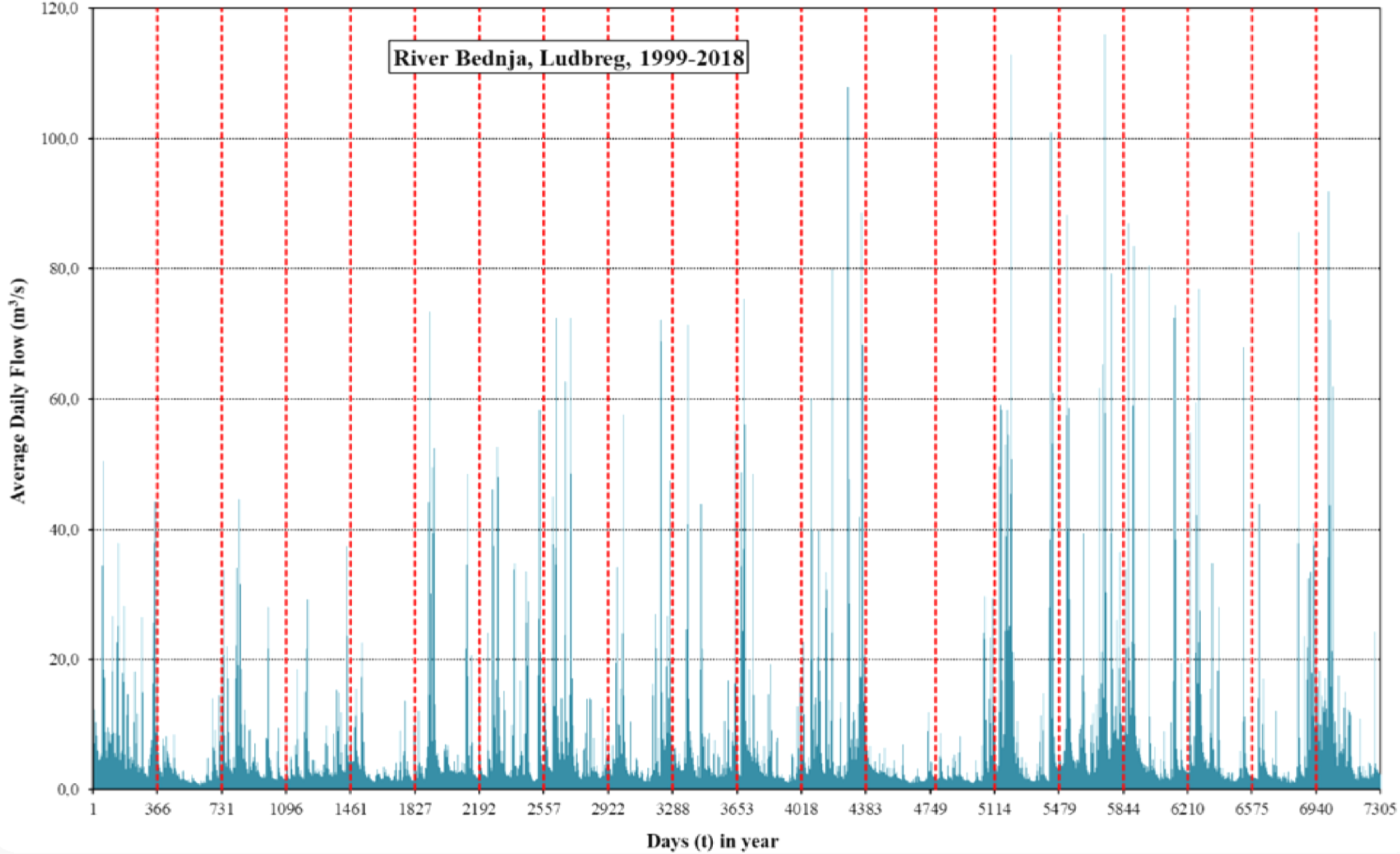
- HYDROLOGICAL (LIMNIGRAPH) STATIONS WHERE TIME SERIES OF THE AVERAGE DAILY FLOW WERE TAKEN ARE LUDBREG (BEDNJA), TURKOVIĆI (GORNJA DOBRA) AND MOTOVUN (MIRNA).

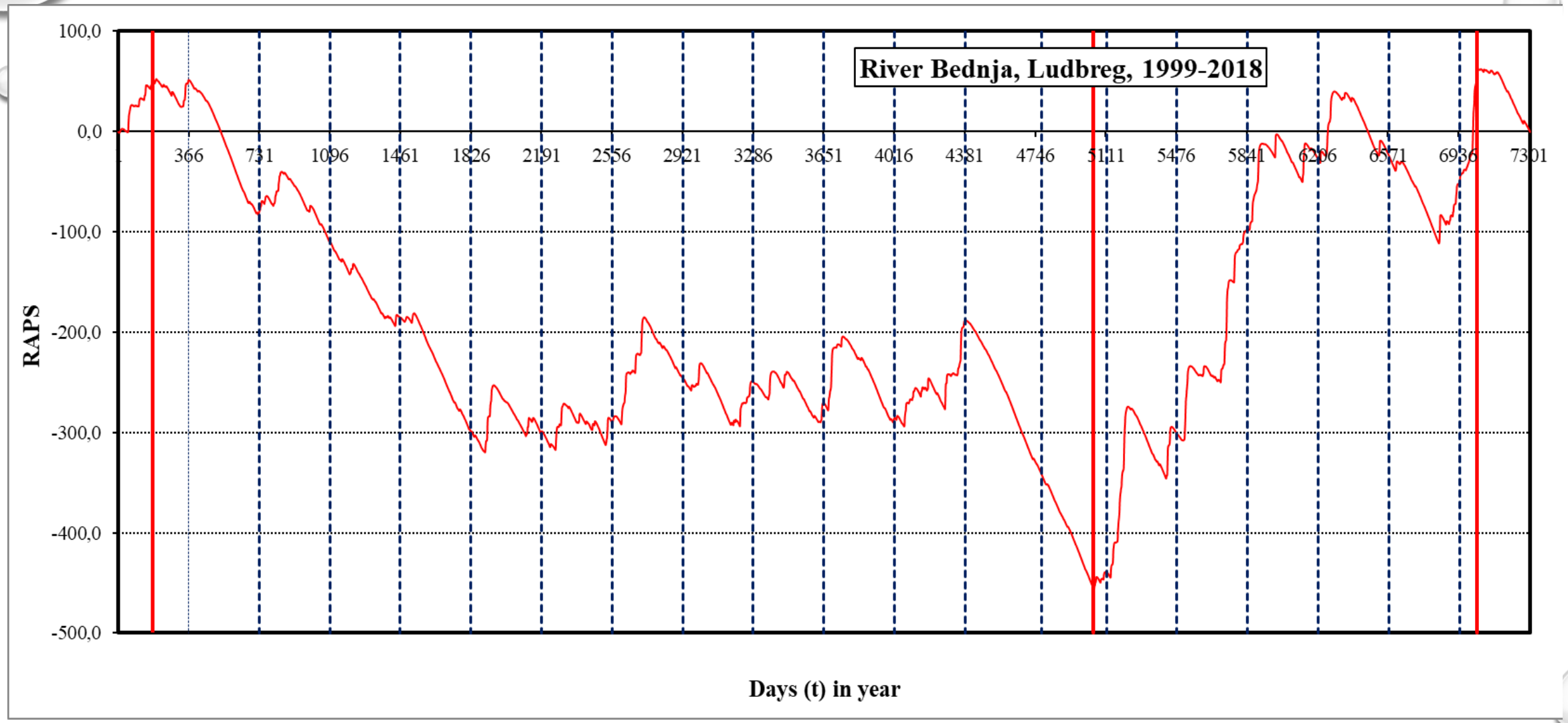
RESULTS AND DISCUSSION

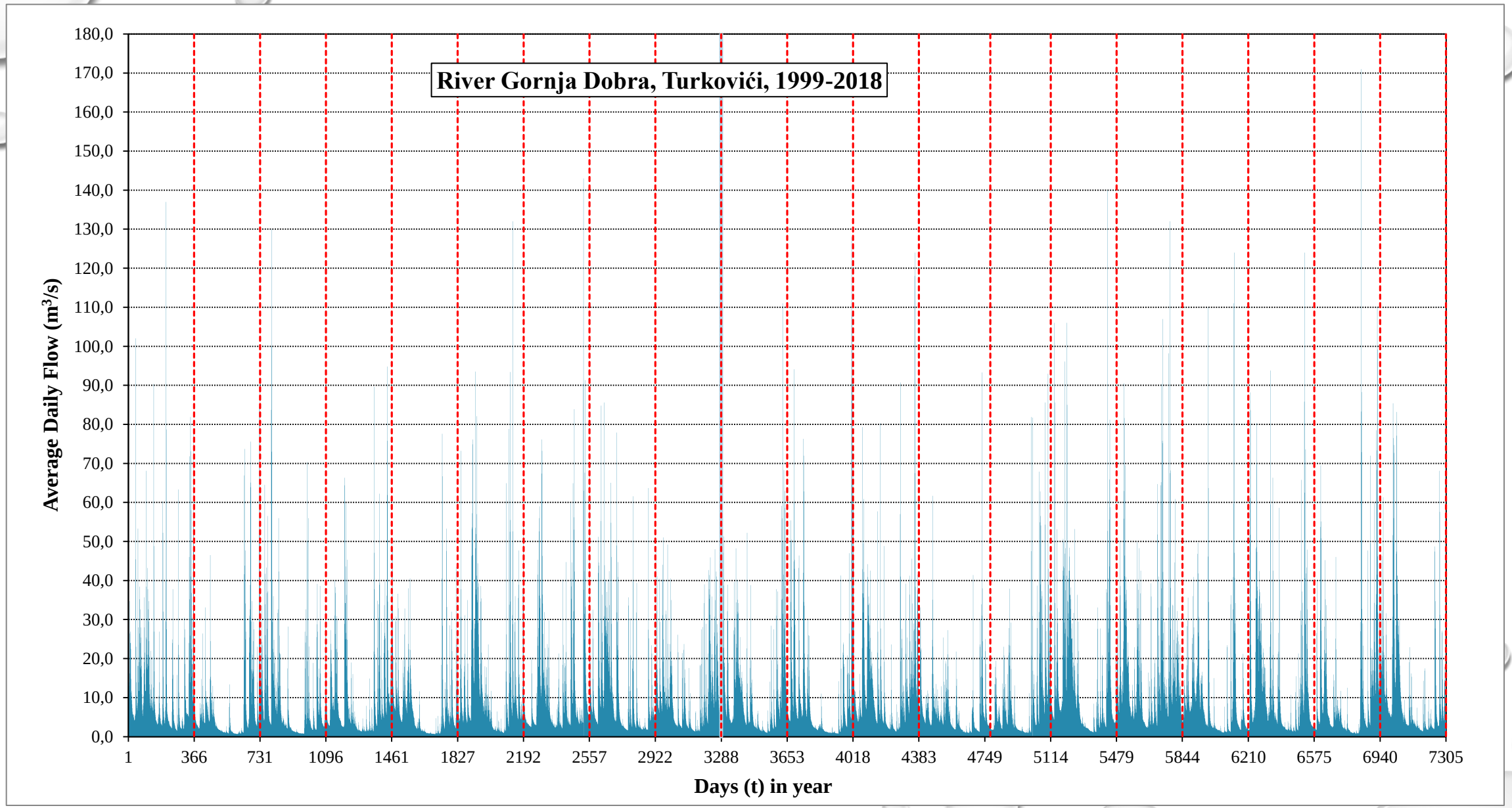
- RAPS DIAGRAMS FOR THE FLOWS MEASURED AT THE MEASURING STATIONS ON THE RIVERS BEDNJA, GORNJA DOBRA AND MIRNA FOR ANALYSED PERIOD OF 20 YEARS, FROM 1999 TO THE 2018.
- GENERAL CONCLUSION IS THAT ALL THREE RIVERS HAVE TORRENTIAL CHARACTERISTICS, WHICH COULD BE SEEN FROM THE HYDROGRAMS.
- PRECIPITATION CAUSES A VERY FAST RISING OF THE HYDROGRAMS AFTER MINIMUM ONE DAY AFTER THE PRECIPITATION ENDS, AND VERY SHORT LAG OF THE ALIGHTING.
- ALSO, DURING SUMMER PERIODS, I.E. MIDDLE OF EACH OBSERVED YEAR, IN MOST OF THE CASES IT COULD BE CONCLUDED THAT FLOWS ARE THE SMALLEST IN COMPARISON TO THE ENTIRE YEAR.
- YEARS WITH SMALLEST FLOWS, 2011 AND 2012, ARE COMMON FOR ALL ANALYZED RIVERS.

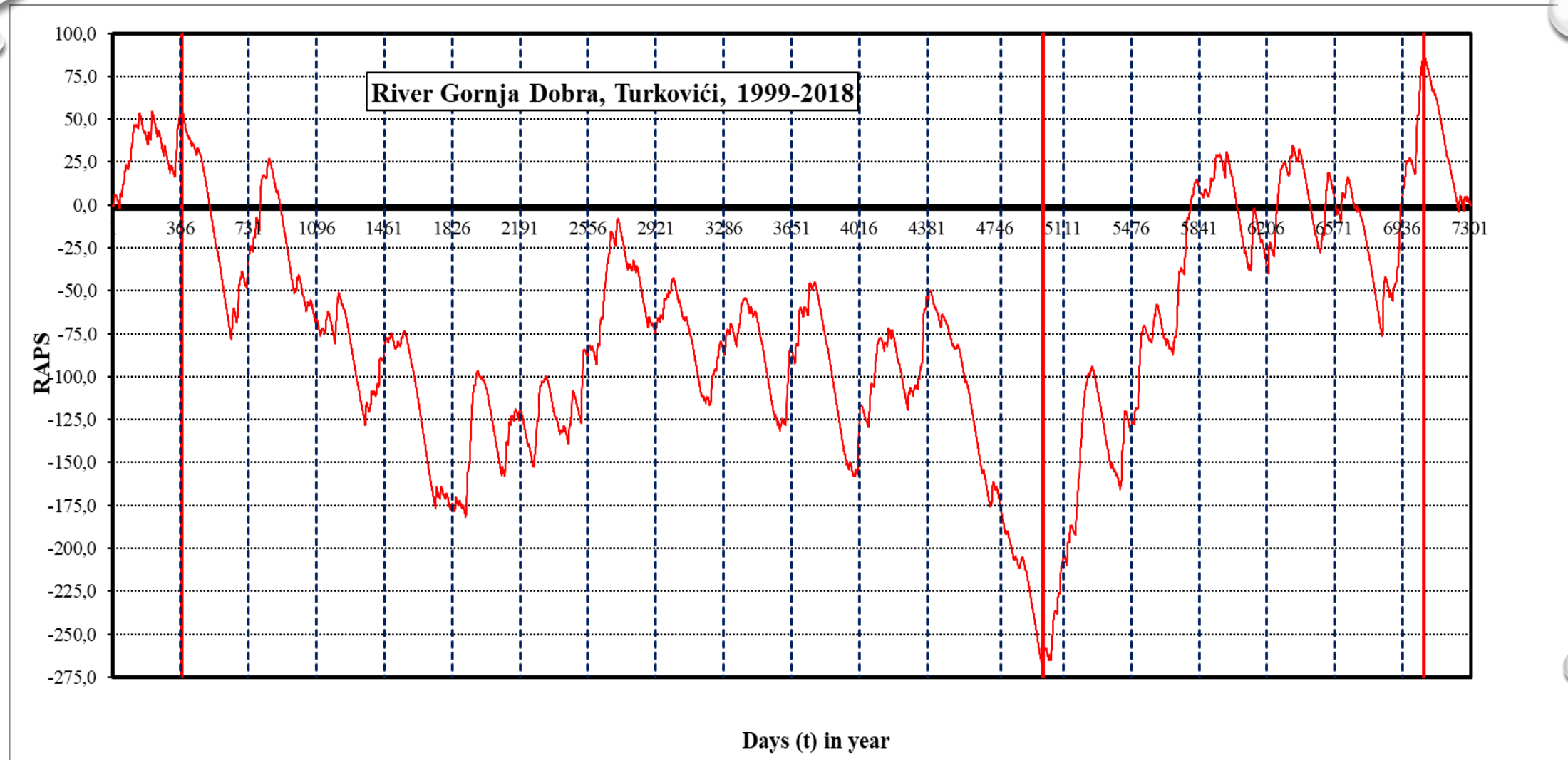
Table 1. Statistical parameters of the average daily flows for river Bednja, Gornja Dobra and Mirna

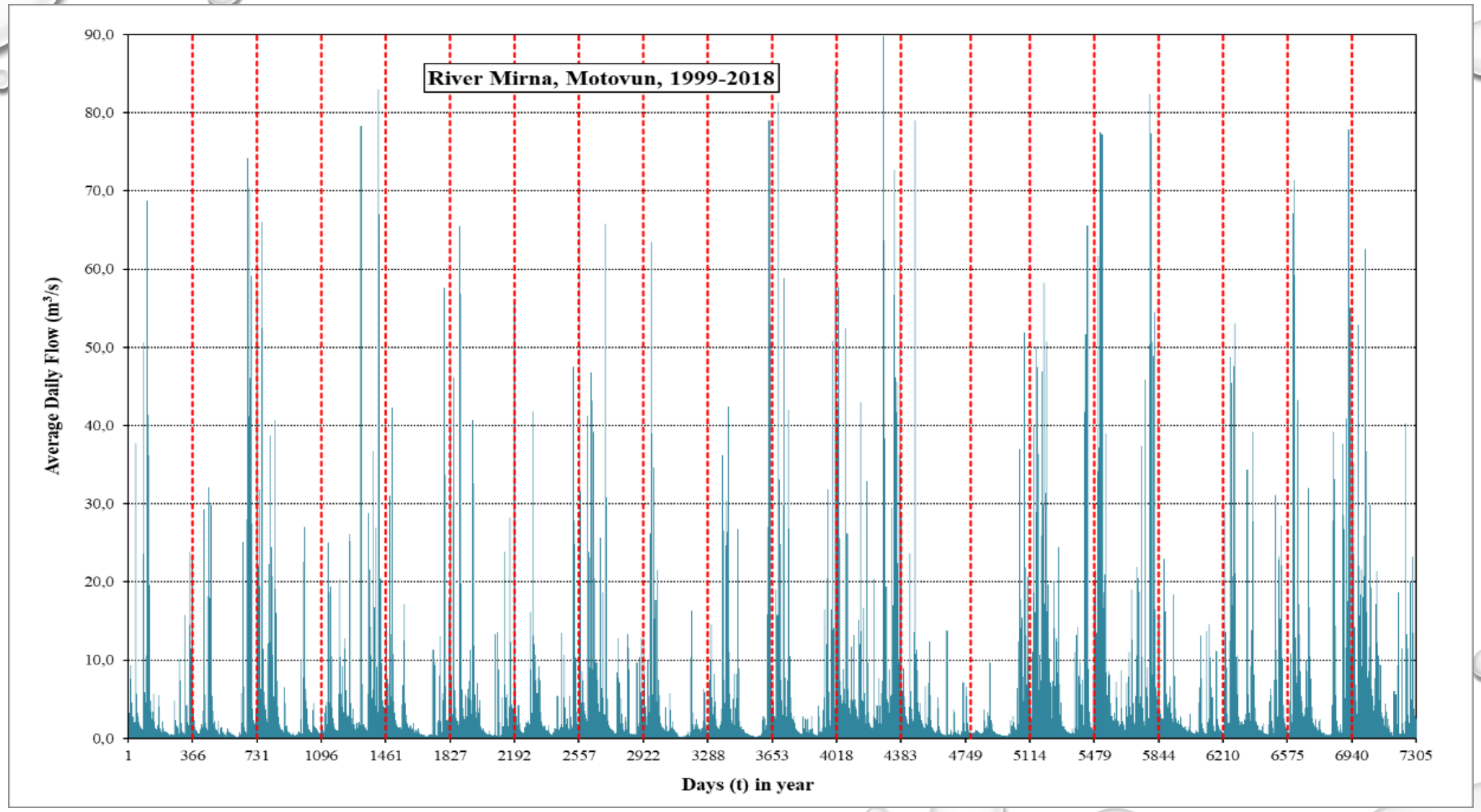
River	Average (m^3/s)	Standard deviation (m^3/s)	Minimum (m^3/s)	Maximum (m^3/s)
Bednja	6,171	9,980	0,431	116,000
Gornja Dobra	11,727	15,414	0,627	171,000
Mirna	5,559	9,909	0,061	89,800

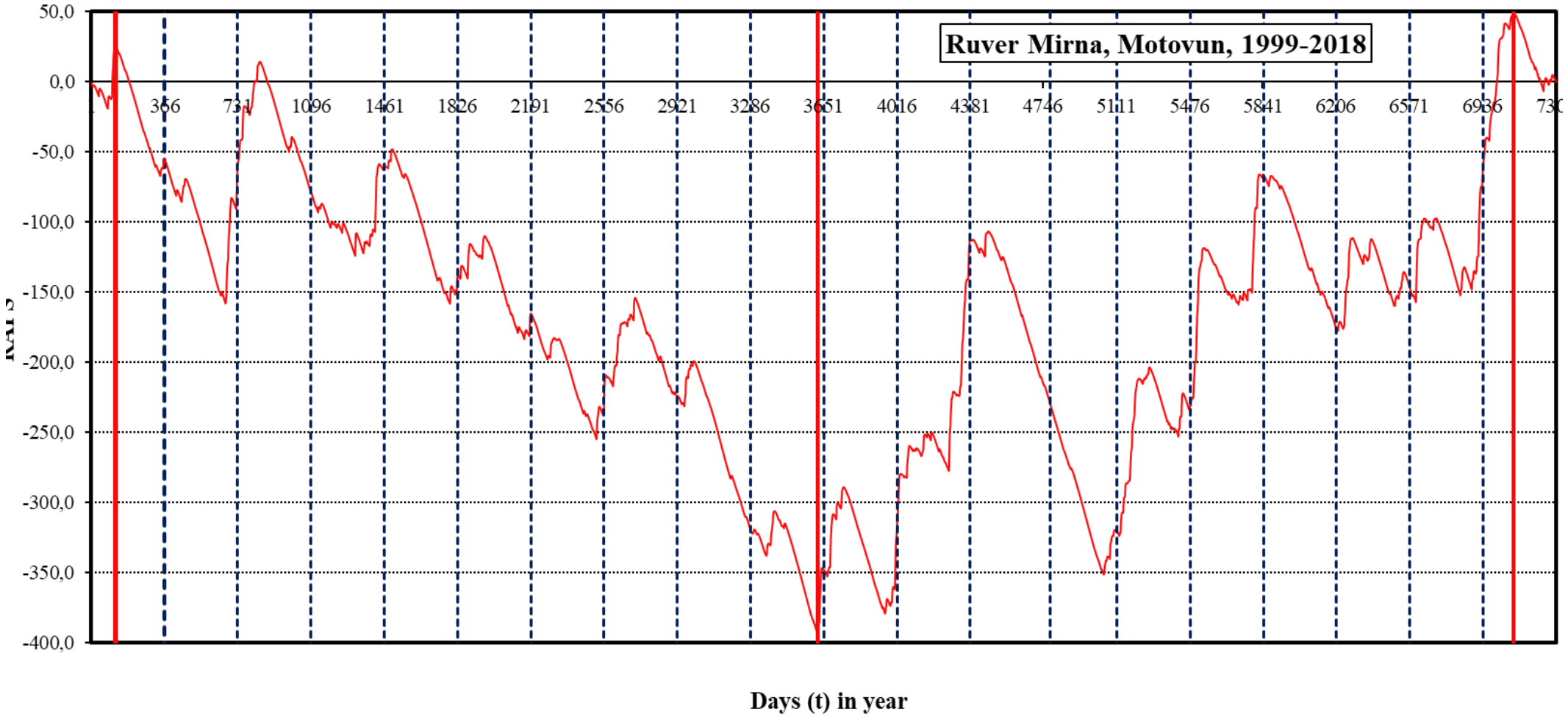

River Bednja, Ludbreg, 1999-2018
Average Daily Flow (m³/s)
120,0
100,0
80,0
60,0
40,0
20,0
0,0
1
366
731
1096
1461
1827
2192
2557
2922
3288
3653
4018
4383
4749
5114
5479
5844
6210
6575
6940
7305
Days (t) in year


River Bednja, Ludbreg, 1999-2018
RAPS
100,0
0,0
-100,0
-200,0
-300,0
-400,0
-500,0
366
731
1096
1461
1826
2191
2556
2921
3286
3651
4016
4381
4746
5111
5476
5841
6206
6571
6936
7301
Days (t) in year


River Gornja Dobra, Turkovići, 1999-2018
Average Daily Flow (m3/s)
180,0
170,0
160,0
150,0
140,0
130,0
120,0
110,0
100,0
90,0
80,0
70,0
60,0
50,0
40,0
30,0
20,0
10,0
0,0
1
366
731
1096
1461
1827
2192
2557
2922
3288
3653
4018
4383
4749
5114
5479
5844
6210
6575
6940
7305
Days (t) in year


River Gornja Dobra, Turkovići, 1999-2018
RAPS
100,0
75,0
50,0
25,0
0,0
-25,0
-50,0
-75,0
-100,0
-125,0
-150,0
-175,0
-200,0
-225,0
-250,0
-275,0
366
731
1096
1461
1826
2191
2556
2921
3286
3651
4016
4381
4746
5111
5476
5841
6206
6571
6936
7301
Days (t) in year


River Mirna, Motovun, 1999-2018
Average Daily Flow (m³/s)
90,0
80,0
70,0
60,0
50,0
40,0
30,0
20,0
10,0
0,0
1
366
731
1096
1461
1827
2192
2557
2922
3288
3653
4018
4383
4749
5114
5479
5844
6210
6575
6940
7305
Days (t) in year


Ruver Mirna, Motovun, 1999-2018
50,0
0,0
-50,0
-100,0
-150,0
-200,0
-250,0
-300,0
-350,0
-400,0
366
731
1096
1461
1826
2191
2556
2921
3286
3651
4016
4381
4746
5111
5476
5841
6206
6571
6936
Days (t) in year

DISCUSSION

- REGARDING HYDRO-ENERGY POTENTIAL, SUCH ANALYSIS INDICATES THAT IN CASE OF OCCURRENCE OF THE SUBSERIES WITHIN ORIGINAL TIME SERIE OF THE FLOW, ATTENTION SHOULD BE FOCUSED ON THESE PARTS OF THE ANALYZED TIME PERIODS.
- SPECIFICALLY, IN ANALYZED CASES, PERIODS FROM YEAR 2018 ARE INTERESTED BECAUSE THERE ARE PRESENT IRREGULARITIES, WHICH AFFECT AVERAGE DAILY FLOW SERIES. CALCULATION OF THE FLOW REQUIRED FOR SIZING OF THE HYDROPOWER PLANTS SHOULD BE FOCUSED ON THOSE VALUES IN SUCH SUBSERIES.
- THIS SURELY DEPENDS ABOUT DURATION OF THE AVAILABLE TIME SERIES (10, 20 OR LONGER), BECAUSE RAPS CALCULATION WILL NOT SHOW SAME DIVISION OF THE GIVEN TIME SERIE.

View at the measuring station Ludbreg on river Bednja

View at the measuring station Turkovići on river Gornja Dobra

View at the measuring station Motovun on river Mirna

CONCLUSION

- REGIME OF THE WATER FLOW BY APPLICATION THE RAPS ANALYSIS OF THE AVERAGE DAILY FLOW SERIES, TOGETHER WITH REVIEW OF THE HYDROGEOLOGICAL CHARACTERISTICS.
- ALL ANALYZED RIVERS HAVE POTENTIAL FOR BUILDING OF THE SMALL HYDROPOWER PLANTS.
- DETAILED ANALYSIS, I.E. EXTENSION OF THE RESEARCH WILL INCLUDE ANALYSIS OF THE OTHER MEASURING STATIONS ON THE ANALYZED RIVERS AND ESTABLISHING OF THE FUNCTIONAL CONNECTIONS BETWEEN FLOWS MEASURED ON SEVERAL MEASURING STATIONS.
- FIELD MEASUREMENT AND PROSPECTION ON THE POTENTIAL LOCATIONS, WHERE INSTALLATION OF THE HYDROPOWER PLANTS IS POSSIBLE, AND WHERE DATA DOES NOT EXIST, EVERYTHING WITH REGARDS ON THE HYDROGEOLOGCAL PROPERTIES.
- NUMERICAL ANALYSIS SHOULD INCLUDE RAPS ANALYSIS OF THE PRECIPITATION TIME SERIES, AS WELL AS OF EACH PARTICULAR TIME SERIE OF THE AVERAGE DAILY FLOW IN ORDER TO OBTAIN COMPLETE PICTURE OF THE ANALYZED AREA.

THANK YOU!