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Slavoljub Dragićević
Nenad Živković
Vladan Ducić

FACTORS OF FLOODING ON THE TERRITORY OF THE MUNICIPALITY OF OBRENOVAC

Abstract: Frequent floods in the area of the municipality of Obrenovac have initiated the establishing, classification and analysis of the starting factors of their genesis in this area. After the dam had been constructed on the right bank of the Sava River (in the 80's of the 20th century) along the northern border of the municipality of Obrenovac, there were no more floods in this part of the area caused by its overflows. Recent floods have still been caused by a very frequent flooding of the River Kolubara near Poljana, even several times during the year. For that reason the factors of flooding the Kolubara River from its riverbed have been analyzed in this paper. Except the pluviometric and hydrological regime analysis as direct factors of flooding, the indirect causes have also been analyzed in details, the most important of which are: the morphological characteristics of terrain, balance of deposits and anthropogenic impacts. Perceiving the causes of flooding, the conditions for analysis of undertaken measures and giving the possible solutions for their prevention have also been realized. The results of this research can be used in making the strategy for solving the existing waterpower problems of this area.

Key words: natural disasters, floods. Obrenovac, the Kolubara River

Садржај: Честа појава поплава на простору општине Обреновац иницирала је утврђивање, класификацију и анализу одредишних фактора њихове генезе на овом простору. Након изградње насипа на десној обали Саве (80-тих година 20. века) дуж северне границе општине Обреновац, нису се више дешавала плављења овог простора њеним изливањима. Рецентна плављења су и даље условљена веома честим изливањима реке Колубаре код Пољана, чак и више пута у току године. Из тог разлога, у овом раду су анализирани фактори изливања Колубаре из корита. Осим анализе плувиометријског и хидролошког режима, као директних фактора настанка поплава, детаљно су анализирани и индиректни узроци, од којих су најважнији морфолошке одлике терена, биланс наноса и антропогени утицаји. Сагледавањем узрока настанка поплава остварени су и услови за анализу предузетих мера и изношење могућих решења за њихово спречавање. Резултати овог истраживања могу се искористити при изради стратегије решавања постојећих водопривредних проблема овог простора.

Кључне речи: природне непогоде, поплаве, Обреновац, Колубара.

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Introduction

The municipality of Obrenovac lies on the right bank of the Sava River, between the districts of the villages of Usce and Baric, on the contact of the several geographic regions. The total area is 410 km^2 and regarding the physical-geographic aspect it mainly borders on natural borders, while only its smaller part is bordered on the administrative division. The total length of the borders is 127.1 km, whereof 77.9 km belong to the border of water currents. The Sava River represents the border course in the length of 38.42 km, the old course of the Kolubara River functions as a border in the length of 21.6 km, the Tamnava River 9.3 km and the Vukodraz River 8.56 km. The mentioned data are very important because they talk directly about the surroundings of the municipality by water currents of different categories. Except its "coming out" on several rivers, the territory of the municipality is intersected by several permanent and periodical water currents, as well as by the canal system made for the purposes of the waterpower. The number of water currents influences directly the predisposing of the terrain for the phenomenon of very stressed surface runoff, what certainly has as a consequence the possibility of flooding the given territory (Драгићевић, 2007-а).

Main factors of flooding

In order to make an analysis of the natural conditions for the phenomenon of floods in some area, a complex examination of direct and indirect reasons which cause their genesis is necessary. Floods originate by one-sided or multiple influences of many factors, as natural so the anthropogenic ones. However, according to the main cause, the types of floods in our country can be distinguished as the following: floods caused by rainfall and snow melting, cold floods, floods caused by the coincidence of high waters, torrential floods, floods caused by sliding of terrain, floods caused by demolition of dams (Гавриловић, 1981). According to the mentioned classification, in the area of the municipality of Obrenovac floods can be caused by almost all mentioned reasons. The probability of flooding caused by demolition of dams is small one for now, but on the basis of plans for the water accumulation constructions in the upper part of the river basin of the Kolubara, this phenomenon cannot be completely eliminated in future.

Precipitation as a factor of flooding

If we make a retrospective of the flood phenomenon, as well as of hydrological occurrences in this area from the last year, we will get a clearer idea on the importance of analyzed problem. In spring of 1924, a great part of the municipality of Obrenovac was flooded. During March of the same year, about 80 mm

of ground water extracted from the river basin of the Kolubara, while in April twice more precipitations approximately. The precipitation maximum, characterized by intensive rainfalls, was recorded in Valjevo between April 17th and 22nd. Under the influence of such climatic occurrences, water flooded 18 km in width, and the whole periphery of Obrenovac lay in water (Гавриловић, 1981).

As V. Djekovic (1986) wrote: "In 1926, unsuitable meteorological situation brought to flooding the Kolubara River and its tributaries. According to the narrations of the local residents it had not been known where the course both of the Kolubara and other tributaries was."

Catastrophic floods of the Sava, Kolubara and their tributaries also spread over the area of the municipality of Obrenovac during the spring of 1937, and they lasted two months approximately (from March to May). Floods also happened in 1965, 1975, 1981 in this area. After the construction and improvement of dams during the 80's, there were no large scaled floods in this area, but every time they were spreading over the village of Poljana. However, it is important to emphasize that it does not mean there were not natural conditions for the large scaled floods because the absolute water level maximum in the river basin of the Kolubara was appearing in 1996, and then in 1998, 1999, 2001, 2004, 2006.

On June 1996, the absolute water level maximum was recorded in the hydrological stations of Beli Brod on the Kolubara River, Pastric on the Ribnica River and Bogovadja on the Ljig River, while in the station of Drazevac the maximum water level recorded was insignificantly lower than the absolute maximum values.

On June 13th 1996, namely, the river basin of the Kolubara was under a downpour due to extreme weather conditions, while the former amount (174 mm) recorded in the station of Lazarevac has represented the highest daily precipitation in the river basin of the Kolubara, the fourth in the whole area of Serbia. The return period of three hour rainfall in some stations was one thousand years (Вукмировић и Капор, 1999). Such weather conditions caused a sudden wave of high waters in the Kolubara and its right tributaries with the absolute maximum in four hydrological stations. On the basis of the pluviographic record for the station of Valjevo the intensity of precipitation was established on this station. In only thirty minutes, 39 mm rained, and that is a sufficient index of the characteristics of such downpour.

The recent analyses have shown (Драгићевић, 2002) that the precipitation which corresponds to the average value for a given month can be extracted in many of the stations of the Kolubara river basin even during a day (30.07.1999). Precipitation in the liquid form with considerable intensity is especially dangerous in winter, and if it happens that it coincides with snow melting then it can cause extreme climatic conditions similar to those in the area of the Kolubara river basin on December 1999.

Rains in summer half of the year, i.e. in June and July mostly influenced the flooding of the area of the municipality of Obrenovac and substantial increase of annual amount of precipitation in all stations in 1999. It is interesting to point out that in July of the mentioned year the amount of precipitation in some stations was equal the half of mean annual precipitation for period 1961/90. In other words, half of a long average precipitation amount was extracted in July 1999. Only in July 1999, 328 mm was registered in Obrenovac, while a long average precipitation amount for this town is 647 mm for period 1961/90. This means that 31% of annual amount of precipitation (1999 – 1057 mm) fell in Obrenovac in July. The same month, 236 mm were recorded in the station of Stubline, while a long mean amount of precipitation was 695 mm.

Daily precipitation values were significant in many of the stations on July 30th 1999, 56 mm were measured in Obrenovac on that day, while 58 mm on July 31st. This means that 114 mm were for two days while average thirty years long value for the same month in this station is 59 mm. In other words, the amount of precipitation was extracted in many rain-gauge stations during only a day (July 30th) which practically corresponds to the total precipitation for given month.

On the basis of such analyses it can be said that in accordance with characteristics of pluviometric regime of analyzed area the precipitation maximums appear at the end of spring and at the beginning of summer while the secondary maximum appears at the end of autumn. On the basis of 1961/90 period analysis it can be noticed that June is most rainy month with 84 mm while February is the driest with 40 mm in the station of Obrenovac. If we analyze the amount of precipitation of a wider area (Region of Belgrade), the arrangement of precipitation is such that there is one clear peak in June (characteristic for larger part of Serbia) and then May and July follow (Живковић и Драгићевић, 2003). Analyzing the precipitation data for 27 rain-gauge stations in the river basin of the Kolubara, the balance is the following: maximum precipitation appears in 25 stations in June while in only two stations the maximum appears in May. In these two stations the difference between May and June precipitation values is less than 5 mm, so that practically they also have precipitation maximum at the end of spring (Драгићевић, 2001). On the basis of precipitation analysis as a factor of flooding on the territory of the municipality of Obrenovac we can say that the precipitation is significantly caused by the characteristics of the pluviometric regime.

Floods in the river basin of the Kolubara can also be initiated by the sudden snow melting which appears due to sudden daily air temperature increase originated as a consequence of warm and wet air masses penetration. In combination either with rainfalls, or without them, 30 cm of snow blanket can be melted in period of 3-4 days. This situation makes conditions for flooding which have already been explained on the basis of the analysis of climatic conditions in December 1999 (Драгићевић, 2002).

Overflow as a factor of flooding

The Kolubara River is probably the most beautiful example of obtaining almost all conditions for frequent and large scaled floods. They can be analyzed starting from the shape of the river basin and the coefficient (0.79), very rare in nature, position and orography being a gust of wet air masses from the northwest, considerable deforestation and torrential characteristics of many tributaries, lithologic and pedologic characteristics in the lower part of the river basin, weak retentive power and favoring the surface runoff, human activities under coal digging and moving the river courses, etc.

All mentioned factors as well as the local ones in some sub basins lead the Kolubara River to have unsuitable water regime. This is reflected through the excessiveness of runoff waters, while overflows are sudden, expressive, short, and low waters are long and every year they are approaching the biological minimum. As an index of unsuitable runoff characteristics the relation of absolute extreme discharges is usually taken, thus placing the Kolubara into the very top among our rivers (similar in surface). With the maximum discharge in Drazevac which exceeds 700 m^3/s and minimum about 0.6 m^3/s the quotient is about 1200, while in Valjevo even 3400. Divisor (Qamin) is more dynamic in this relation so that by its small change the quotient considerably grows (by reducing on 0.3 which is not unexpected as for example by doubling the highest waters on 1400 m^3/s the quotient grows on 2400). This is why is better to use characteristic discharges (certain return period) instead of absolute values. By the relation of a hundred year high water (1%) and average annual discharge (period 1946-91) the Kolubara in Valjevo has the value of 83, and 36 in Slovac. While the rivers of its rank considerably reduce this quotient by surface increasing, it is kept on the same level up to Drazevac although the surface has been enlarged more than 3.5 times. This was mostly contributed by tributaries, the mouths of which are in the Donja Kolubara basin, and the river basins are usually torrential in character (Ljig, Pestan, Turija, Tamnava with Ub). Among the river basins with similar surfaces (3000-4000 km^2), quotient of the Lim (Prijepolje) has the quotient 15, the Zapadna Morava (Gugaljski Most) 23, the Juzna Morava (Grdelica) 27, the Nisava (B, Palanka) 20, etc. The data from Gornja Kolubara show what the values in the lower rivers are Centennial high waters exceed the mean ones for 55 times on the Gradac, on the Obnica 130 times, the Jablanica 160 while on the Ribnica even 220 times (268:1. 22 m^3/s) (Водопривредна основа Србије, 1996).

Large oscillations of the Kolubara waters and uneven runoff during the year can be shown by the coefficients of the mean month discharge variations. For the purpose of the comparison the river basins of the similar surfaces have been used in the previous paragraph.

It is obvious that month discharge oscillations of the Kolubara River for all months exceed all other rivers. Besides, even 4 months (July, August,

October and November) exceed Cv of 0.1 (1.67 from August is the consequence of almost incredible 104.5 m^3/s recorded in 1955). At the beginning of the year, in period of high waters, more stable discharges can be expected, even though they are over 0.7. Because of that in the whole period of 55 years not even two similar hydrographs of month discharges can be found what is very unusual for this river.

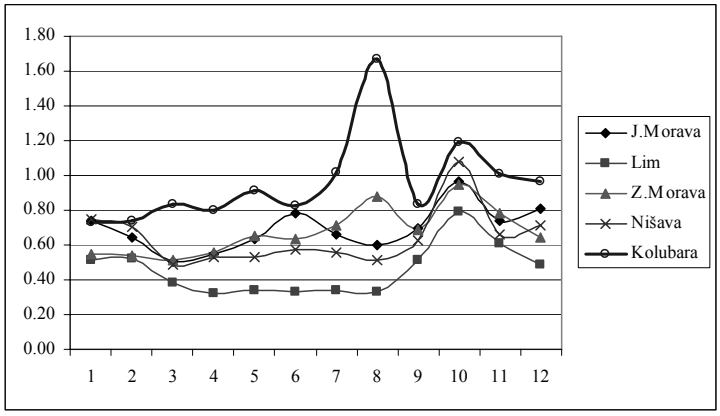

Figure 1. – Coefficients of month flow variation of the Kolubara (Drazevac) and chosen river basins in Serbia (1946-1991)

One more reason lies in the relation of the surface and underground runoff. Considerably larger participation of the first one shows weak drainage and retentive power of the river basin, that is, its torrential characteristics. Although the river is being supported only from the groundwater most of the year, almost one third of waters flow out of it in Drazevac, while it is better upstream (35-43%). According to the same index the worst is in the river basins of the Pestan, Ljig and Tamnava (up to 30%), while the most suitable is in the Jablanica and Gradac (over 40%) (Оцокољић, 1993/94). According to what it has been written so far it would seem that the Kolubara belongs to watery rivers. However its runoff coefficient is only 25% at the mouth, while its specific runoff is 5.8 $l/s/km^2$. This coefficient is 35%, 9.5 $l/s/km^2$ in Slovac (the Gornja Kolubara), while under the influence of evaporation in the Donja Kolubara the runoff is 4.4 $l/s/km^2$ (Slovac-Drazevac inter basin).

Morphological characteristics of terrain as a factor of flooding

On the basis of analyses of pluviometric and hydrological regime, it is absolutely clear that floods are mostly caused by a combined effect of direct and indirect factors in the municipality of Obrenovac. The effect of direct factors has already been explained, and as it can be seen it is manifested with sud-

den melting of snow blanket, high intensity rainfalls and sometimes coincidence of both factors.

The indirect causes of flooding certainly need to be especially analyzed, where the morphological characteristics of terrain are the most important ones. Studying the hypsometric, morphometric and geomorphological characteristics represent necessary basis for the analysis of the natural conditions and dominant factors of flooding in the examined area. Therefore, in order to get a clear picture on the characteristics of the observed terrain, the hypsometric map of the municipality of Obrenovac was made. It has been established that 56.3 % of the territory of the municipality of Obrenovac lies on the altitude which is lower than 100 m, that is, 92.2% of the territory of the municipality (378 km^2) lies up to 200 m altitude, i. e. the largest part belongs to plain. Height includes less than 8% of the eastern part of the territory of the municipality, that is, right valley of the Kolubara River. On the basis of calculation the data show that the mean altitude of the territory of the municipality is 112 m (Драгићевић, 2004).

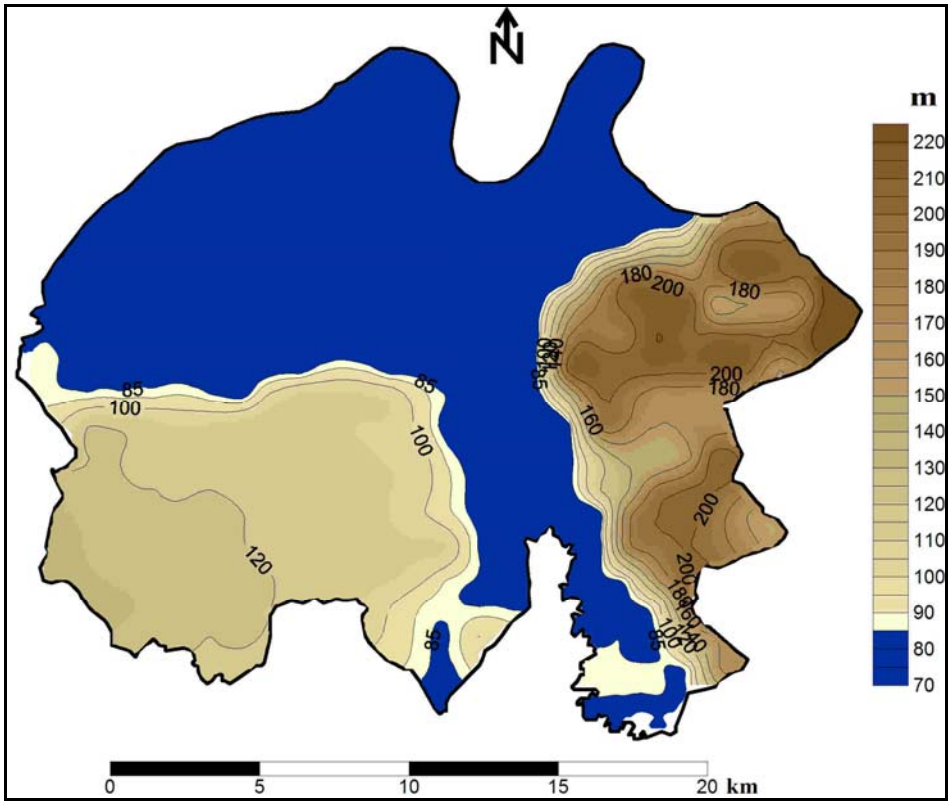

Figure 2. – Endangered areas by floods on the territory of the municipality of Obrenovac

This map represents the starting point in the terrain analysis, potentially endangered by floods. On the basis of the terrain researches it has been established that floods were appearing in the areas lower than 85 m altitude. Below 80m altitude there are 126 km^2 of analyzed area and if it is separated on the hypsometric map, potentially endangered areas by floods would be obtained.

However, it is important to point out that presented areas on the map used to be flooded, and now they have been marked as potentially endangered zones by floods. Due to dam construction during 80's of the 20th century the areas that used to be flooded were considerably reduced, while nowadays the district of the village of Poljana has been endangered most.

Except the hypsometric characteristics of the area, the morphological ones are also important. In hydrological sense, the river basin of the Kolubara (where most of the municipalities lie) is round in shape, which means fast flowing of atmospheric waters into the main river, having as a consequence the sudden increase of the water level and discharge. However, depending on the speed, the flooding wave is also distinguished by short time of keeping.

Frequent floods in the area of Poljana demand universal morphological analysis of the Kolubara riverbed. If we ignore the climatic conditions, the main causes of floods in the lower course of the Kolubara are large winding of the river and small depths, having the consequence of covering the riverbed with deposits. On the basis of the recent researches (Драгићевић, 2002) it has clearly been established that in the middle and lower part of the Kolubara course it comes to the accumulation of great part of the river deposits.

Table 1. – Transfer of suspended deposits in t/year in the stations of Beli Brod and Drazevac on the Kolubara River according to RHMS (Republic Hydrometeorological Service) measures

Станица	1985	1986	1987	1988	1989	1990	1991	1992
Б. Брод	101,532.3	106,619.5	115,448.8	52,230.6	65,792.0	3,275.7	26,881.9	24,490.6
Дражевац	71,474.8	118,939.0	90,483.3	43,217.6	73,113.3	11,348.7	42,793.4	22,180.0

On the basis of the data from the table it can be noticed that in four years of analyzed period (1985-92) the larger deposit transfer was accomplished in more upstream station than in more downstream one (Драгићевић, 2002). In other words, in the inter basin between B. Brod and Drazevac it comes to the accumulation of material, more exactly, to covering of the riverbed. As a result of this covering, the reduction of moistened profile appears having thus the consequence of more frequent floods in the area of the municipality of Obrenovac. On the basis of estimate it was found out that in the mentioned period the imbalance was 22,721.3 t i.e. that much of material was accumulated in the inter basin between these two hydrological profiles.

In order to obtain more reliable results the period of observing the transfer of covering has been extended On the basis of incomplete twenty years long

series for period 1985-2004, a clear imbalance of deposits between these two hydrological profiles has been confirmed. According to the data from given period, it is obtained that 193,253.8 tons of material were accumulated between these two hydrological profiles, that is, the riverbed itself was raised for 36 cm. By the previous, shorter series, the datum has been 4.2 cm, while now it is nine times enlarged. This should be accepted cautiously due to already determined methodological mistakes of measuring of suspended deposit concentration and also due to the mistakes in the calculation of deposit transfer (Dragićević i dr., 2006).

On the basis of the previous analyses it has clearly been proved that the accumulation of material has been expressed in the valley of Donja Kolubara. By subsequent, detailed measuring the most downstream hydrological profile has also been included on the Kolubara River, the profile in Obrenovac. It is situated under direct slowing down of water caused by the water level variability of the Sava, so it was supposed that a very expressive accumulation of material had to appear between Drazevac and Obrenovac. Thus an entirety would be completed, that is, the phenomenon of the river deposit accumulation would be established between B. Brod and Drazevac, but also between Drazevac and Obrenovac. During 2003 and 2004, the decrease of deposit transfer on the downstream profile was confirmed by the comparative analysis of the deposit transfer on the profiles of Drazevac and Obrenovac. In 2003 13,997.3 t were accumulated in the riverbed of the Kolubara between Drazevac and Obrenovac, while during 2004, 19,605.3 t of the river deposits were accumulated. The basic hypothesis on the intensive covering of the riverbed in the lower part of the course of the Kolubara River has just been confirmed (Драгићевић, 2007-б).

As a result of the river deposit accumulation in the riverbed of the Kolubara there are numerous accumulations of the river material presented by islands and sandbanks. It is interesting that the islands have been formed in the course of the Kolubara immediately after its formation in the very valley of Valjevo. If we analyzed the map of the relief energy of the researched area it would be clearly noticed that isoline-90 was very expressive, which meant that the terrain was under the accumulation of material. The map of the first trend of the relief energy of the Kolubara river basin (Драгићевић, 2002) has shown that almost whole terrain north from Valjevo mountains has been under tectonic movement of slow sinking what is also noticeable on the map of the first trend of the relief energy of Serbia (Манојловић и др., 2004) where the sinking is expressed north from the 270. km, observed along the y axis. The situation on the terrain definitely shows the credibility of the map, while the meandering of the Kolubara riverbed from its origin to its mouth just contributes to the previous statements.

Taking the existence of distinctive concave banks in the lower sector of the Kolubara course into consideration, it is expected that strong side erosion is followed by later accumulation of material. That is clearly noticed in the area

of Poljana where on the whole course of the Kolubara (border course) the effect of side erosion which is expressed by meandering of the concave banks and river material accumulation, is being changed alternatively.

Figures 3-4. Concave bank and inland-island in the riverbed of the Kolubara in Poljana

Therefore, a significant speed reduction of the courses appeared, having the consequence of turning, i.e. meandering of the riverbed. Today, there are numerous fossil fluvial shapes, i.e. cut off meanders and deserted riverbeds (Dragićević i dr., 2006).

Anthropogenic impacts on floods

Anthropogenic impacts on the river system can be divided into direct and indirect. Direct impacts mean numerous engineering works of the riverbed regulation of the water currents themselves and they include the channeling of the whole sectors of the riverbeds but also the protection of the concave banks, the construction of water accumulations with the aim of regulating the river regimes, redirecting the riverbeds, etc.

The largest actions were in the area of the middle flow of the Kolubara River. Their aim was to turn the courses in order to make space for the farther lignite exploitation. In the sector between Vreoce and Poljana, the Kolubara has changed its natural course for several times, moving from extremely meandering into almost straight course. Significant morphological changes on the Kolubara and Pestan were in 1976. as the consequence of moving the course of the Kolubara aiming to make wider the strip mining of lignite. Its riverbed moved 800 m upstream from the mouth of the Pestan which led to fossilization of the old riverbed of the Kolubara from Vreoce to Poljana. Deserted riverbed of the Kolubara was provided to accept larger flooding waves and thus it had an important function for a very long time.

The mentioned moving of the Kolubara course reduced the phenomenon of very frequent and large floods in the area of the municipality of Obrenovac. In the sector of Poljana, the Kolubara had an extremely meandering riverbed which could not be able to accept some flooding waves so that by the mentioned action the number of such disasters was reduced. The total length of the fossilized riverbed of the Kolubara is about 37 km. However, from the mouth of the Kladinica into the Kolubara in most part of the year water flows through the cut off riverbed of the Kolubara (the length of 19.6 km) so even today this part has the characteristics of the periodical course, but not completely deserted riverbed.

As it is noticed, every moving of the Kolubara riverbed demanded also the lengthening or shortening the riverbeds of its direct tributaries. In the last 80 years there were drastic morphological changes in the riverbed of the Pestana for several times. Before the regulation of the Kolubara, the Pestan River emptied into it near Drazevac, and it received the Turija, its largest tributary, near Stepojevac. After the regulation, the height difference of the bottom of the Pestan River and the bottom of the Kolubara was 3.8 m due to which 150 m long rapid course in natural material was formed. (Ђековић, 1986). This brought to the regressive erosion in the riverbed of the Pestan thus initiating new

regulative works, bearing new consequences. The total length of deserted riverbeds of the Pestan is 7.2 km.

By adding the River Kolubara into the riverbed of the Pestan, a general deformation of the Kolubara riverbed appeared. Permanent process of sinking of Donja Kolubara valley and the Kolubara- Pestan splitting had a consequence of covering the riverbed by deposits with an aim of exceeding the stadium of the disagreed side profile and reaching the stadium of agreed profile.

Discussion and conclusion

Natural disasters follow man throughout the whole history. However, people did not just observe the phenomena but they gave their best to use all their experience in order to have as fewer consequences as possible. That struggle with nature was not just out of spite but the need to use other natural resources situated very often in the area of disaster itself (lignite strip mining). When people could not defend, they began to construct their settlements far from banks, only risking with temporary buildings and nursery plants near rivers. Developing the systems and regulating the water currents, the settlements, and the industrial zone especially, were brought down along the river itself. However, it is important to emphasize that after all prognosis and works, man is never safe in the character of the river.

How many times "the safest systems" in the world went through tragically and people were paying with their lives and destruction? And if floods cannot be eliminated, how can they be reduced? By complex works in the river basin and on the dams by the river, away from the bank and so high that even "the most incredible water" cannot exceed them. This sounds good, but why it wasn't thus reacted anywhere in the world? Because, these actions are very expensive, unprofitable economically and unsustainable ecologically. It can be concluded that the defense system is the product of importance of material goods in the river basin, that is, decisiveness of the community to defend them. If it was not so, we would not speak on the floods as of the natural elements but as of the phenomenon going on in some river basin without people and goods.

Almost the whole concept of flood protection in Serbia is based on the classical, passive principle of defense, where dams represent the basic means for the protection of coast. While the river corridors of the high rivers of the Danube, Sava, Tisa and Velika Morava are even several kilometers wide, the dams of middle and low water currents are often placed by the riverbed itself. Thus, their dimensioning is reduced to the defense from waters of short return period which seriously endanger their aim under the excessive climatic conditions in the last few years. 243 km of dams have been constructed in the river basin of the Kolubara so far and how much they are important the datum shows

that high centennial water endangers 17000 ha of the most fertile soil. Along the Kolubara itself these ramparts were placed from the mouth of the Savas River to the mouth of the Tamnava River and from the mouth of the Turija to Lazarevac, i.e. Lajkovac. Although they give a certain safety to the rear, the stochasticy of the high water phenomenon of the Kolubara is such that there is no complete safety there.

Since floods are the phenomenon of the river regime of waters, the technical measures by which the flooding zones have been limited and measures by which it has been influenced the flooding discharges, may have complex effects, i.e. except the desired consequences they can also have the unwanted ones. What is certain is the fact that man significantly contributed the increase of the flood frequency in the area of Poljana. Namely, when dams were strengthened and completed in the area of the municipality of Obrenovac during the 80's of the last century, the area of Poljana was left completely unprotected. One of possible reasons that was mentioned was the need for the security zone which should represent the protection of the town center itself, and the territory of Poljana was the one to be " sacrificed ". Was it the only one solution of the problem or it was just temporary, or just one of the possible solutions, all these are discussible. One is certain, it had to be a temporary solution, i.e. the problem that has demanded and it is still demanding urgent solution.

By the complex analysis of all mentioned factors, we can come to a conclusion that the topographic conditions on the very course of the Kolubara do not permit any dam construction and making the accumulation basins that could accept flooding waves. Such sort of the protection may be carried out on the tributaries of the Kolubara, especially on those with torrential characteristics of the river regimes. The most efficient way of flood defense in the river basin of the Kolubara is the channeling of the riverbed or the construction of dams or constructing several accumulation basins located on the tributaries.

Planned construction of several small accumulations on the tributaries of the Kolubara has still been at its primary phase, without signs for solving the existing water problems. However, it is necessary to emphasize that the first phase of flood protection includes arrangement of the river basin and sub erosive works but also the usage of the intensity of erosion caused by reduced impact of anthropogenic factor (Драгићевић и Степић, 2006), it can be said that the first phase has been realized and there are conditions for the realization of the second one, i. e. the construction of accumulations. In the regional strategy the construction of 8 accumulations in the river basin of the Tamnava River has been planned, 5 in the river basin of Ljig, two each on the Kladnica, Toplica, Rabas, Ribnica, Gradac, Obnica and Jablanica.

About the channeling of the Kolubara for sailing, i. e. for the needs of Kolubara lignite export by river transportation, it is still insufficiently thought

about, although the initiative appeared long time ago. The river was navigable only 3 km from its mouth, lately. Under mean water levels the mouth of the Kolubara into the Sava lies on about 70 m altitude, while the terrain around Vreoce is on 93 m. The height difference of 23 m and wide riverbed of the Kolubara would make easier its channeling, enabling cheaper transport of Kolubara lignite. Invested means for the river channeling and its preparation for river transportation would certainly economically be excused (Дукић, 1974) n the lower course of the Kolubara the regulation of its riverbed could easily be carried out. Thus, the meandering flow would be straightened, but the strong side erosion in the very riverbed would be regulated so that some factors of flooding would be eliminated.

Dredging the river deposits from the riverbed of the Kolubara was stopped, while once well known whirlpools in its course were calmed. Although the river deposits were hand extracted with low intensity, it certainly had great positive effects from the aspect of maintaining the surface of moistened profile. Such simple measures do not demand considerable investments on the removing the existing situation on the terrain and they can be carried out without special limits of the natural conditions.

All mentioned solutions demand a complex analysis of the condition, but also the development of the strategy the priority of which would be both to solve the existing water problems in this area and to provide necessary conditions for farther lignite exploitation.

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Славољуб Драгићевић
Ненад Живковић
Владан Дуцић

ФАКТОРИ НАСТАНКА ПОПЛАВА НА ТЕРИТОРИЈИ ОПШТИНЕ ОБРЕНОВАЦ

Резиме

Природне непогоде су појаве које прате човека кроз читаву његову историју. Људи, међутим, нису остајали неми посматрачи тих појава већ су се трудили да сва своја искуства искористе како би последице биле што мање. У сливу Колубаре је до сада изграђено 243 km одбрамбених насипа, а колико су они важни показује податак да стогодишња велика вода угрожава 17.000 ha најплоднијег земљишта. Дуж саме Колубаре ови бедеми су постављени од ушћа Саве до ушћа Тамнаве и од ушћа Турије до Лазаревца, односно Лајковца. Иако они дају извесну сигурност свом залеђу, стохастичност појаве великих вода Колубаре је таква да ту нема и потпуне безбедности. Наиме, када су током осамдесетих година прошлог века појачани и дорађени одбрамбени насипи на простору општине Обреновац, простор Пољана остављен је у потпуности незаштићен. Као могући разлог истицана је потреба постојања сигурносне зоне која би требало да представља заштиту самог градског језгра, а за ту зону је "жртвована" територија Пољана. Да ли је ово било

једино решење проблема или је то било само привремено, или једно од могућих решења, остаје дискутабилно. Једно је сигурно, то је морало бити привремено решење, односно проблем који је захтевао и сада захтева хитно разрешење. Комплексном анализом свих наведених фактора, може се закључити да топографски услови на самом току Колубаре не дозвољавају изградњу брана и стварање акумулационих басена који би прихватили поплавне таласе. Овакав вид заштите од поплава оправдано је извршити на притокама Колубаре, посебно на онима са бујичним карактеристикама речних режима. Најефикаснији начин одбране од поплава у сливу Колубаре је каналисање корита и изградња насипа поред њих или стварање већег броја мањих акумулационих басена лоцираних на притокама.