HYDROLOGIC CHARACTERISTICS OF THE DANUBE RIVER IN THE REPUBLIC OF SERBIA

CARACTERISTICILE HIDROGEOLOGICE ALE DUNĂRII ÎN SERBIA

Svetislav SOSKIC, Jovica CURCIC [1]

Abstract: Regarding the influence of the Danube hydrological features on navigation, primarily flow rate and water level, is great. They directly work on speed, latitude and depth of the waterway. We considered and handled with statistic data provided by the hydrological stations Bezdan, Novi Sad and Smederevo from 1985 to 2004.

Key-words: hydrologic characteristic, the Danube, Serbia
Cuvinte cheie: caracteristici hidrogeologice, Dunărea, Serbia

Introduction

The system of internal waterways (IWW) in Serbia includes navigable rivers, canals and lakes. The waterway of the Danube River with its tributaries and the Danube-Tisa-Danube (DTD) canal system represent the unique system of the Black-Sea basin (which receives the largest part of our flowing rivers).

The important communication ways from the Middle Europe toward the Near East and vice versa run through this area. The system of IWW spreads in the direction NW-SE with transversal communications, which widely extend from the Danube River and its tributaries. Together with land communications, the waterways make beam of communications known as 'communication beam of the 45th parallel'. The most important place on that waterway, which at the same time represents the communication hub, is Belgrade.

Economies of many European countries rely on the Rhine-Main-Danube canal system, where daily turnover amounts up to a few billion of American dollars. The Danube Convention, which was signed by majority of the European countries for providing an undisturbed navigation along the Danube, confirms the interest for this waterway (Fig. 1, Fig. 2).

There is a plan to connect Belgrade with the Thessalonica port, by a canal which will run trough the Vardar - Morava valley. Besides the Republic of Serbia,

---

[1] Department of navigation, Military academy, Belgrade, Serbia

other European countries are interested in this project as well, due to the fact that the waterway from the Middle Europe to the Suez Canal and farther will be shorten.

Figure 1. Waterway of the Danube River

Figure 2. The pan-European traffic corridor VII

The internal waterways are rivers, canals and lakes, whose width and depth provide a safe navigation.

36

The River-Canal system of Serbia consists of three sea basins: Black-Sea, Adriatic and Aegean. The areas of those basins and their average sizes are given in the Table 1 (Dukic, D. 1977).

Table 1 Features of the three sea basins

Sea basin	Basin area		Average basin size	
	Square km	%	length in km	width in km
Black-Sea	81,703	92.4	343,.5	238.0
Adriatic	4,732	5.4	75.0	63.0
Aegean	1,926	2.2	72.5	26,5
Serbia	88,361	100.0	484,0	182.0

Source: Dukic, D. 1977

The total area of Serbia is 88,361 square km (Dukic, D. 1977). The Black-Sea basin is the largest and covers the area of 81,703 square km, that is 92.4% of the total territory. The main rivers of the basin are the Danube and the Sava with their tributaries, the Tisa with its tributaries, the Velika Morava with its tributaries, the Drina, the Kolubara, and the Timok. The Aegean basin covers an area of 1,926 square km or 2.2% of the Serbian territory. The main rivers are the Lepenac, the Pcinja, and the Dragovistica. The Adriatic basin covers the area of 4,732 square km or 5.4% of the geo-space. The main river is the Drim with its tributaries, (Sekulovic, D. 2004).

The average length of water flows on the area of 1 square km of a basin can be obtained by using (Dukic, D. 1977) the Nojman' pattern. It depends on many parameters and the most important are: climate, especially geologic structure and relief and vegetation. The average density of the river system in our Karst terrains permeable to water is only 0.05 km/square km, in plains terrains of Vojvodina, which lack in precipitation it is only 0.075 km/square km, and in our mountain terrains with normal erosion it is 0.70 km/square km. The river system of Serbia is 65,980 km long or averagely 747 km/square km.

The Danube

The Danube is an international river, which is, after the Volga, the longest river in Europe. It connects the South-Eastern Europe with the North and the West (Hamburg and Amsterdam), and at the same time it represents a direct and cheap way toward oil and natural gas of the Caspian Sea and the Caucasus Mountains. The Danube divides Europe in two parts - North-Eastern and South-Western. It has it source at the foot of the mountains of Schwarzwald. It is made of two smaller rivers, the Brega and the Brighat, which join near Donaueschingen at 687 m above sea-level. The Danube is an important navigable river of the Middle and South-Eastern Europe. By connecting with the Rhine, the big navigable canal, which was completed in 1981, the Danube was included in the system of the Western

European waterways. Thus, the unique 3,400 km long waterway was made. It connects the North Sea with the port of Rotterdam at the mouth of the Rhine, and the Black-Sea with the port of Sulina.

The Danube has big water-management importance for ten Danube-basin countries it flows through or represents the natural border of countries on the opposite banks: Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria, Moldova, and Ukraine. The basin of the Danube includes bigger parts of Slovenia and Bosnia and Herzegovina, as well as smaller parts of Switzerland, Italy, Czech Republic, Poland and Albania.

Therefore, the Danube receives water from 17 countries, so it is rightly taken as 'the most international river' in the world.

Due to its importance, the water-way of the Danube was proclaimed the pan-European traffic corridor VII (Picture no. 2). About 140 millions of tones turnover was realized annually through this waterway, and through the Serbian part of the Danube 40 millions of tones. It should be kept in mind that river transport is four times cheaper than railway and fourteen times cheaper than road transport.

Downstream navigation of a motor ship from Rotterdam to Sulina lasts 11 days, and on the way back it lasts 17 days, while a pusher with lighters would spend 14, that is 19 days.

The Danube enters the territory of Serbia at NKM[2] 1433 about 8 km upstream from the village of Batina. The general direction of the Danube extent over the territory of Serbia is northwest-southeast. The river stream is broken, so some parts have an approximate north-south direction (from the entrance to the territory of Serbia to the city of Vukovar, than east of Fruska Gora, a short part east of Belgrade, in Djerdap – the Iron Gate and part from the village of Kostol to the mouth of the Timok). All other parts of the Danube stream, which, at the same time, represent the biggest length of the stream in our country, have the general direction northwest-southeast, and in some parts they have the west-east direction.

The Danube basin (Dudik & Gavrilovic,)[3] is asymmetrical: its right side covers 44%, and left side 56% of the basin area. The basin asymmetry coefficient (ac) is an important hydrological indicator, especially for the basins of big rivers. The right side of the Danube basin, even though smaller, gives to the Danube 66%, and left side only 34% of the water flowing through its bed; the explanation for this difference can be found in bigger precipitation amount and more favourable conditions of its outflow from the Alps and the Dinaric Mountains.

Width of the The Danube River
The width of the Danube River during small or medium water level is almost the same, because during these water levels the river remains in its narrower bed,

---

[2] NKM - navigable kilometer - mark of the mileage measured from the mouth to the Black Sea upstream
[3] D. Dukic, Lj. Gavrilovic: Hydrology, ZUNS Belgrade, p. 90

which has fairly steep and uniform banks. During high and very high water levels, predominantly right side, and dam on the left side makes flood areas.

The average width of the Danube through Serbia is 600 m. It is the widest at the entrance to the Iron Gate Gorge, up to 2000 m, and the smallest width is in the Gospodjin vir Gorge, 132 m, where the Danube[4] has the biggest depth - 82 m. The width of the Danube during small and medium water level, which corresponds to the width of the narrower river bed, in some places is considerably different, but in the main lines it can be noticed that it grows from the Danube entrance to the territory of Serbia to the Iron Gate, than in the Iron Gate it narrows, and when it flows out from the Iron Gate it gets wider again.

From its entrance to Serbia all the way to the Iron Gate, the Danube has two characteristic sections according to the width of its bed:
- from the Hungarian border NKM 1433 to Slankamen NKM 1217, during medium water level the Danube has an average width of the water mirror from 350 to 500 meters,
- from Slankamen to the Iron Gate NKM 1048 the Danube has an average width from 500 to 800 meters.

The Danube is supplied by atmospheric precipitation, which flows together down the slopes of exalted basins, with thawed snow and ice, as well as with abundant underground waters. Along the stream, the supply is different: in the upper part of the basin, the above mentioned factors have a dominant role, while the lower part of the basin receives water from surface and underground waters.

In the city of Uzice, the average annual precipitation level is 791mm, in Belgrade 687mm, Sremska Mitorivca 652mm, Novi Sad 620mm and Palic 538mm, and at the east part of the country in Leskovac 601mm, Nis 551mm, Bela palanka 526mm, Zajecar 641mm, Golubac 617mm and Bor 706 mm. In Potisje, north of the village of Backo Petrovo Selo, the average annual precipitation level is 600 mm, approximately as in Deliblato Sand, Veliko Pomoravlje, in the valley of the Southern Morava to the Grdelica Gorge, in the Western Pomoravlje to the city of Trstenik, in the major part of the Ibar valley, in Kosovo and the lowest part of Metohija.

The altitude elevation of the Danube River's floor
The altitude elevation of the Danube River's bed floor is 72.30 meters at the entrance to the territory of Serbia, and 20.00 meters above sea-level at the way out at the mouth of the Timok River, which means that an average fall of stream is about 0.09 meters per kilometre. However, the fall of the stream floor in some parts of the stream suddenly varies. In some parts, the altitude differences are up to 15 meters at a distance of a couple of kilometres (Military-engineer description of the Danube River, 1960). The lowest continental height above sea level in Serbia (27 meters during medium water level) is at the mouth of the Timok River into the Danube.

---

[4] This depth is the maximum sounded river depth in Europe

From the viewpoint of the navigable characteristics, the Danube, on its way through Serbia, can be divided in four parts: from the Serbian-Hungarian border to Belgrade, from Belgrade to the Iron Gate 1, from the Iron Gate 1 to the Iron Gate 2 and from the Iron Gate 2 to the mouth of the Timok River.

The Danube River basin has temperate-continental climate.

Latitude, atmospheric circulation and relief are causes of big differences in air temperature in the Danube basin. The mean temperature in the coldest month – January varies from -1°C to -4°C. The temperature in the warmest month – July, in Schwarzwald, in the Alps, is 14°C, in Bavaria 16-18°C, on the middle Danube 17-22°C, and on the lower Danube 22-24°C.

Water temperature

The water temperature varies depending on the season of the year. Firstly, it is connected with air temperature and sun radiation, but also with the water temperature of the Danube tributaries. The maximum water temperature in July and August averagely is 18-19˚C in the part of the upper Danube and 24-26˚C in the part of the lower Danube.

Water flow

As a consequence of the precipitation unevenness, snow thawing, underground and other waters, in different period of a year, the Danube water flows vary a lot. Differences between minimum and maximum reach 29 times in Linc and 6 times in Bogojevo. The physical – geographic conditions of the basin considerably influence the big quantity of the mean multi-annual water flow. Severe changes are characteristic only for the upper stream. The characteristic of the parts of the Danube with wide basin areas and plain relief is that when the water level changes rapidly, floods occur.

The unit, which indicates the flow, is cubic meter per second (m^3/s).

The tables which indicate the flow values usually include the following parameters: year, elevation 0, daily, month and annual flow values.

Daily flow values are measured in the water gauges. Daily data refer to minimum, maximum and mean month flow values. Maximum, minimum and mean annual flow is calculated based on the month flow values (Table 2).

'Elevation 0' represents the height above sea level where a hydrologic station is located.

The average water flow through the Iron Gate is 5,750m^3/s. In the territory of Serbia, the Danube tributaries increase the total water quantity for about 3,100m^3/s (the Sava in Belgrade 1,690 m^3/s, the Tisa about 945 m^3/s and the Velika Morava about 520 m^3/s).

Water level

The most important parameters for the navigation are water level and its variation. Ship commandants need data concerning water levels for determining

40

probable depths on waterways in shallow spots and pier areas, as well as for determining axes of navigable canals and borders of the river bed navigable part.

Table 2 Monthly flow values

| Weather station	Distance from Sulina (km)	Flow (m³/s)		
		min	max	mean
Bezdan	1,428.6	863	6,200	2,177
Novo Selo	834	1,526	13,840	5,569
Svistov	554	1,624	14,404	5,941

Source: *Dukic, D. 1977*

Now, in the regulated stream of the upper Danube, where there are located 7 dams with reservoirs, there remained only 4 shallow spots; in the middle or Pannonian stream of the Danube, there are 58 shallow spots, and in almost the same length long lower stream of the Danube, there are only 16 shallow sports, that is averagely 1 on every 58 kilometres.

A water level varying in some parts of the river depends on weather conditions in the first place, and, often, on the quantity and intensity of precipitation, height of snow cover and character of the weather during snow thawing. Staggering impact on water levels drop and form beds and its asperity, intensity of channel deformations, the appearance of ice, wind regime and the regulation of channel.

The Danube River has a complex water level regime, but water level characteristics can be defined by periods: flood, mean height and winter period.

The water level varies a lot and it is different in various parts of a flow (Fig. 3). The highest water level is in April and May when snow thaws in the stream of its tributaries, and the lowest in autumn. High spring waters appear up to two times a month. Their rise lasts 15 – 20 days.

Anvelopes are used to show a water level. Those are curved lines, which represent water level changes during a year. Daily water levels on one water gauge station during one year are used for making anvelopes. Anvelopes of maximum, minimum and mean water levels for a certain year or period of time are obtained based on the maximum, minimum and mean daily water level values during a year.
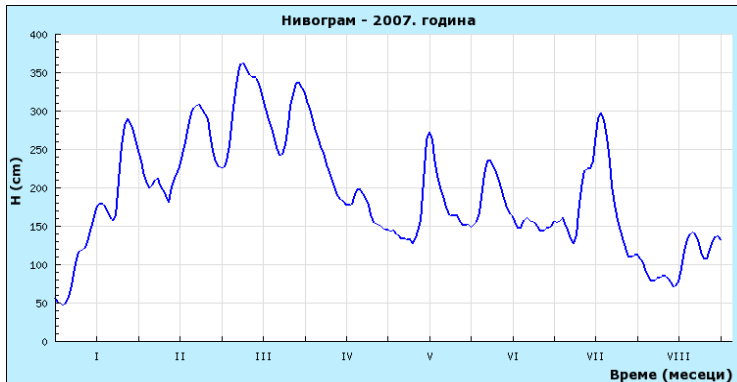
Figure 3. Water level state in Novi Sad in the period between January and August 2007[5]

Depth of the Danube River water

The depth of the Danube River water varies a lot along the entire stream. The averages are:

- during low water level from 4 to 8 m,
- during mean water level from 9 to 13 m,
- during high water level from 11 to 15 m.

The Danube River is the deepest between Apatin and Opatovac, Belgrade and Smederevo and in the Iron Gate (Veliki and Mali Kazan), and it is the shallowest between Ilok and Slankamen, Dubravica and Ram.

The characteristic feature is that, in some places, these depths are much bigger than the average ones in that part of the stream. The most characteristic places with these depths, without including the extreme depths in the Iron Gate Gorge where the artificial lake lies now, are showed in the Table 3[6].

Table 3 Depths artificial lake

Places	During low water level	During mean water level	During high water level
Bezdan	13.5	17.0	20.0
Dalj	26.0	30.0	33.0
Sotin	13.0	16.0	19.0
Novi Sad	11.0	14.0	17.0
Beograd	15.0	18.5	21.5
Vinca	13.0	17.0	20.0

Source: *Military-engineer description of the Danube River*

---

[5] *Taken in September 2007 from* www.hidmet.sr.gov.yu

[6] *Data taken from the book "Military-engineer description of the Danube River, 1960 "*

42

As shown in the table, the average differences between low and mean water levels are mostly 3 m, and the same is between mean and high water levels. The highest water levels on the Danube are from April until the middle of July, which depends on the time used for ice thawing in the area of the stream.

Fall of stream

The general fall of the Danube River, from its source to Sulina, is 678 m, and the mean fall is 0.25m/km. The general fall of the middle Danube is 73.5 m. The fall from Genjija to Moldova Veka is from 0.05 to 0.10m/km. In the part of the Iron Gate, before the hydro system 'Djerdap' was built, the fall in some places was up to 2m/km. The general fall of the lower Danube is 0.344 m/km.

The medium speed of the Danube River stream

The speed of the stream depends on the longitudinal profile of the river bed, water level, bed transversal section, form of the bottom and banks, speed and direction of wind, size of ice cover. The medium speed of the water during low water level average about 0.5 m/s (1.8 km/h), during medium water level about 0.85m/s (3 km/h), and during high water level about 1.40m/s (5 km/h).

Freezing of the Danube

The main Danube bed freezes rarely and only when it is bitterly cold and when the water level is low. Even then the river freezes only in some parts of its stream, but never along the entire river. Freezing of the main bed starts when the temperature is lower than -10°C three or four days constantly, starting from the bank. When the temperature goes under -20°C and when these conditions last two or three days, the whole surface of the Danube in that part of the stream can be frozen. The biggest measured thickness of ice until now has been about 50 cm.

However, the accumulation of ice floes can lead to the even bigger thickness of ice, which is a specific phenomenon. In the period of ice movement in many places ice floes accumulate, which provokes stoppage in water flowing, which further provokes floods upstream. The places where it usually happens are the areas of Bezdan, Bridge of Bogojevo, Daljska krivina, Bridge of Novi Sad, Bridge of Pancevo, the area between Kovin and Dubovica and downstream of Golubac and Iron Gate.

It was registered that such accumulated ice floes formed ice jams, which were dangerous for bridges and waterworks. In such cases those ice jams were broken with explosives.

Freezing (Dukic & Gavrilovic)[7] of our rivers starts after a certain number of frosty days (temperatures under 0°C): on the Backa and Banat canals, on the Begej, the Tamis and the Bosut with tributaries it starts after 7 frosty days – because in those canals and rivers, water flows very slowly, which provokes, so called, static

---

[7] D. Dukic, Lj. Gavrilovic: Hydrology, ZUNS Belgrade, p. 115.

ice formation (water speed up to 0.5 m/s); the Tisa starts to freeze after 7-12 days with frost, the Danube after 15-18 days, and the Sava only after 21 days with temperatures under 0°C, etc.

In (Dukic & Gavrilovic)[8] the Hydrologic Annuals in tables with reports about water there is also shown the information about ice on rivers. If ice stops and if such circumstances last a certain number of days, than for that period before water level, a thick black line is drawn. The ice movement is marked with big black dots. The day following the day when the last dot was put, represents the date when the river liberates from ice. In our country that is usually the second half of February, although the ice on the Danube, in Belgrade, thawed only on 27 March in winter 1928/29. It should be emphasized that that winter was the coldest one in the first half of the 20th century. The thickness of ice was 50 cm, so that farmers from Banat, coming to Belgrade, passed the river in horse-drawn.

The Tisa

The Tisa is the river that in the future may be an alternative way for river transport. It springs in the Ukraine Carpathians and to the mouth into the Danube, in Slankamen, it flows through Ukraine, Hungary and Serbia. It is 965km long. The length of its flow in Serbia is 164km, 6 km of which it is a border river. The area of the Tisa stream is 20% of the entire area of the Danube stream. The average width of the Tisa is about 150m, and in some places even wider: in Senta 220m and in Titel 250m. The depth of the Tisa is from 4 to 12m. The Tisa has a very small fall, averagely about 4 cm/km, which results in its meandering and slow flow (about 0,5m/s). The river's bed is mostly regulated, possibilities of floods are reduced and the navigational conditions of sailing are improved. The geologic bottom composition is mostly sandy and silty. The bed depth is from 4 to 12m. At the mouth the Tisa is 7m deep.

The highest water level of the Tisa is in April and the lowest in October. Winter storages exist at the entrances to canals.

From the navigational point of view the Tisa can be divided in the stream part from the mouth to the dam in Novi Becej (66.1km) and the part from the dam to the Serbian-Hungarian border. The river bed is not significantly indented, it does not have small river islands and backwaters, and levees are relatively close to the high bank, so that the inundations are very narrow. Due to the slow flow, the first ice cover in the territory of Serbia appears on the Tisa at the temperature under -5°C after 2-3 days.

As on the Danube, the strongest wind is the east wind. The winds that blow in this area obstruct the traffic. The wind blows very strongly, because the river runs through the valley. The winds that blow on the Tisa stream are: east wind, mountain wind and west wind.

---

[8] ibid, p. 117.

The most favourable water level for navigation is when the water gauge in Senta shows from +100 to +300cm. The low water level is considered when the water level in Senta is under 0, and high is when the water level is over 500cm.

Due to the unequal water level, certain changes emerge on the Tisa and the Danube, such as slowing up or rising of the river stream speed. When the water level on the Danube is high, and on the Tisa low, than the river slows up all the way to Segedin. If the water level on the Tisa is high, and on the Danube low, the river speed surpasses 5km/h. When the water level is low on both rivers, the river speed is from 1.8 to 2.5km/h.

In the part of the Tisa through the territory of Serbia, stable parameters of navigation and marking for the night-and-day navigation are provided. The weather factors provoke a navigation halt on the Tisa for about 63 days a year, so that the period of the physical navigation is 302 days.

The Sava

The entire length of the Sava is 945 km. It enters Serbia at 178th navigational kilometre near the village of Raca and joins the Danube in Belgrade. The Sava is navigable along its entire length for ships up 1,500 t. The river stream is just partly regulated, because of its meandering stream, with big bends and meanders. Due to the frequent bed change and low banks, it provokes floods, transforming large areas into impenetrable marshes and pools (marshy areas).

The river stream speed is insignificant, from 0.5 to 1m/s. It means that the river speed does not affect speed of ships during the upstream and downstream navigation. Twice a year small waters and twice a year big waters arise, in spring (April, May) and in autumn (October, November.

When the temperature is under -10°C and lasts more than six to eight days, the Sava freezes. In that case, the Sava can be blocked in some places and over the entire width.

The valleys' width around Sava is 11km in the city of Sremska Mitrovica, and 25 km in the city of Sabac. On the Sava there exists only one permanent winter storage, in Bezanija in Belgrade, and numerous temporary winter storages.

The visibility on the Sava is similar as on other rivers and it is characterized by very changeable number of foggy days, from 20 up to 158 days a year. The most frequent winds are east and west winds.

The Velika Morava

The Velika Morava emerges near the city of Stalac by merging the Southern and Western Morava Rivers. It is the longest river in Serbia. It flows into the Danube at the navigable kilometre 1105. The total length of the Velika Morava is 118km. The depth is two to three meters, in some places up to five meters.

The Velika Morava's valley represents a significant area, because, through the Morava-Vardar valley, it connects the Podunavlje area with the Aegean

geographic area, and further through the Marica valley with the geo-area of the Black Sea.

The stream direction is meandering. The bed width is from 50 to 120m, and in the downstream, in some places, it surpasses 200m. In Stalac it is about 100m, wide and downstream from the Bargdan Gorge it is wide up to 250m. The depth is 4m, and in vortexes up to 10m. The highest water level is in March and April. Before the dams were made, the river often had flooded the areas in the width of 5 kilometres. It is navigable for ships when the water level is medium or high from Ljubicevo Bridge to the mouth into the Danube, (about 10km).

The Tamis

The Tamis springs in the east part of the Banat Mountains, and it flows into the Danube in the city of Pancevo, at 67 meters of the height above sea level. It is 352km long, in Serbia 121km. In the village of Jasa Tomic, it enters the territory of the Republic of Serbia, where it flows with its down stream as markedly plains-river, with low and even banks and mud-covered bed. In that part it is very meandering and it makes numerous backwaters and marshes. The highest water level is in April, and the lowest in September.

It is navigable for ships to 1,000 tons, from the mouth all the way to Pancevo (3km), and for ships to 500 tons from Tomasevac to Jasa Tomic, where it is canalized (36km). All the way to Orlovat, it is navigable for smaller ships (74km). The backwater Karasec is connected with the Danube and it is navigable for smaller ships during high water level along entire length (5km).

The most favourable navigation is during the water level of +320 cm in Pancevo, and during the water level of +200 the navigation is stopped. During high water level, the navigation is performed alongside the right bank.

The Begej

The Begej is the biggest tributary river of the Tisa in Vojvodina. It is 244 km long. It flows into the Tisa in the city of Titel at 69 m above sea level.

Almost straight 72 km long canal was made between Tomasevac and Klek. It is navigable for small ships during medium and high water levels, and during low water level the navigation is stopped. 670 t tug boats can navigate along entire canalized length all the way to Timisoara (114 km).

The Begej gives to the Tisa averagely 50 m^3/s of water. Since during spring the flow is up to 450 m^3/s, the surplus is taken to the Tamis by 8 km long canal, which was made upstream of Timisoara. Sometimes during summer, through the canalized Begej it flows 1.5 to 2.5 m^3/s of water, and in that case water is brought to the Begej from the Tamis by other canals. That canal is closed during high water level on the Begej. Navigation is stopped from December to March, due to ice covers.

The canal system Danube-Tisa-Danube

The canal system DTD is a system composed of a few big navigable canals and of numerous smaller canals. The canal system has two purposes: to disburden the main waterway, so that big ships, which cannot go through the canal, can navigate without being disturbed, and to improve fields in Vojvodina.

The base of this canal consists of 80 channels, 24 dams, 16 locks and 6 security barriers. Of the total 929 km, 664.1 km are navigable. For the 1000t ships, 37.9 km are navigable; for the 500t ships, 258.8km are navigable, and for the 200t ships, 28 km are navigable. By building the lock on the Tomasevac-Opovo canal, the navigation along the Tamis in the length of 81.1 km will be provided for 1300t ships, what increased the total length of the navigable canal for 764 km.

The canals of the hydro system 'Danube-Tisa-Danube' pass through 100 inhabited places, under 84 bridges (Fig. 4).
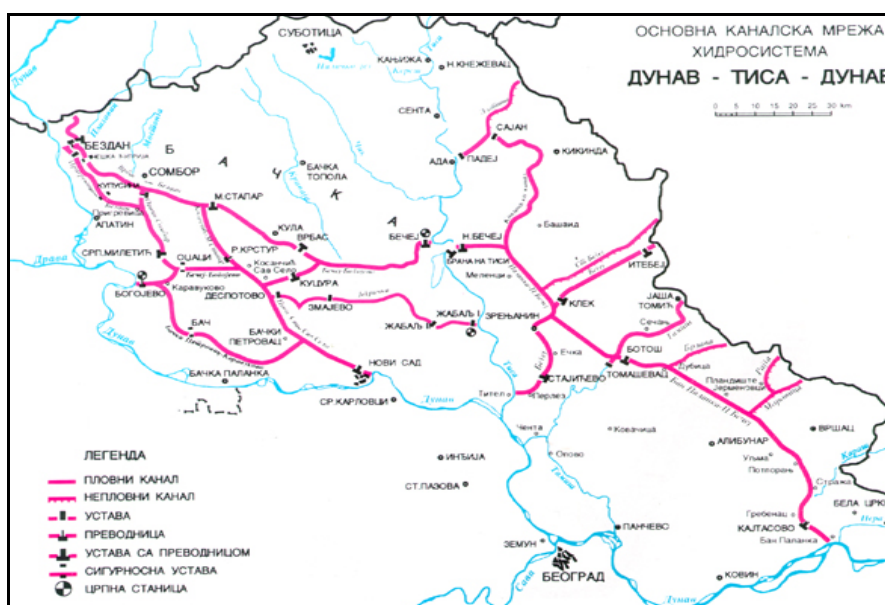

Figure 4. The canal system Danube-Tisa-Danube

REFERENCES

ANTIC, B., (1979), *Inland waterways of Yugoslavia*, Belgrade
DUKIC D. (1977), *Climatology*, Scientific book, Belgrade
TUTUNOVIć, D., (1990), *Nautical's manual of the Danube*, Belgrade
SEKULOVIC, D., (2004), *Generalization of watercourses*, Belgrade
ROSIC, S., (2001), *Hidronavigation and hydrometeorological support of combat operations on IWW*, The New journal, 1/2001, Belgrade
ŽIVANIĆ, S., (1988), *River Navigation*, ZUNS, Belgrade
****Military-engineer description of the Danube River,* (1960)*,* Belgrade
***The Danube Commission, (1993), *General provisions on navigation on the Danube*, Budapest