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HYDROGRAPHYCAL, HYDROLOGYCAL AND QUALITATIVE CHARACTERISTICS WATER WITH REFERENCES ON THE PONTIC SECTOR

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Abstract. Danube. Hydrographycal, hydrologycal and qualitative characteristics water with references on the Pontic Sector. The Danube is the second largest water course in Europe (after the Volga) in terms of length (2860 km) and area (817,000 km^2) The river springs from the central-western part of Europe (Schwarzwald), runs through the central part of the continent, crosses the Pannonian Depression to the confluence with the Drava, then pierces the Carpathian Mountains through the Iron Gate Gorge. Farther down it separates the southern part of the Romanian Plain from the Prebalkan Plateau, and the eastern part of Sea, encompasses the Delta area. In Romania the Danube is 1075 km long and drains 97% of the country's territory. It flows through European regions affected by Oceanic, Baltic, Mediterranean and temperate-continental climatic influences that stamp their mark on the morpho-hydrographic and hydrologic characteristics of the river. The Danube *discharge regime* depends on its upper course tributaries which come from the Alps with high waters in June. In its middle and lower course it depends on the Drava and the Sava, with high waters in spring (April –May) and lower ones in autumn (September – October). The Danube's *multiannual mean discharge* increases downstream as follows: 1,470 m^2/s at Passau, after confluencing with the Inn River; 1,920 m^2/s in Vienna; 2,350 m^2/s in Budapest and 5,300 m^2/s after its junction with the Drava, Tisa and Sava rivers. This water volume enters Romania at Baziaş with 5560 m^2/s. Hence forward values continue to rise through the contribution of its lower course tributaries, reaching 6,495 m^2/s (over the 1840-2016 period) when flowing into the Delta-Ceatal Chilia. *Maximum discharge* is recorded during the high spring waters, but occasionally in summer, too: 15,800 m^3/sec at Baziaș in April 2006; 15,300 m^2/s at Giurgiu, and 15,900 m^2/s at Ceatal Chilia. *Minimum discharge* occur in autumn and occasionally in winter: 1,040 m^2/s at Baziaş 1949; and 1,790 m^2/s at Ceatal Chilia in 1947.The *alluvial discharge* (1840-2000) was 53 million tons/ year, respectively 1,681kg/s, of which 2.81 million tons /year represented coarse alluvia (sands). The extreme values during that interval were 4,470 kg/sec (141 million tons/year) in 1871 and only 229 kg/sec (7.2 million tons/year) in 1990. Throughout that period there was a tendency to decrease at an annual rate of 8.3 kg/year, naturally with fluctuations in terms of the liquid discharge. The *mineralisation degree* is still moderate despite the higher quantities of polluting wastes being spilled into the river in front of large cities – Vienna, Bratislava, Budapest and Belgrade (values coming close to 350 – 400 mg/l due mainly to chlorine and natrium). The Danube's great self-purification capacity makes it recover in the lower course. *The qualitative characteristics of the water* was implemented in 1996 by *Danube Transnational* Monitoring Network - TNMN, the objectives and programs in view of ensuring the concentrations and loads of relevant pollutans and identifyng of the major sources of pollution. The spatial and temporal variation in the pontic sector of the physico-chemical quality indicators, reflect the general characteristics and the effect / impact of the main pressures identified at basin level for the period 1996-2015, in 6 monitoring sections (from Baziaș to Reni). The *type of surface water body* (river, lake, transient water, coastal water) is an aquatic unit that has an aquatic flora and

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fauna determined by the climatic, lithological and morphological conditions of the minor riverbed, hydrological and physical. significant anthropogenic unmodified chemicals.

Key words:Danube, hydrogeographical characteristics, water bodies

1. CONSIDERATIONS OVER DANUBE'S WATER COURSE

1.1. Hydrographic characteristics

Danube, the second longest river in Europe (after the Volga), springs from the Black Forest Mountains (Schwarzwald – Germany, Baden – Württemberg) through the tributaries Breg and Brigach, below the Kandel Peak (1241 m altitude) that confluence at Donaueschingen (678 m altitude). The length of the Danube is ap. 2860 km and has a river basin with a total area of ap. 817,000 km² which it forms together with the 120 tributaries. The Danube is the only European river that flows from west to east, its river basin running between 42° and 50° N latitude and between 8° and 30° E longitude, representing 8.8% of the Europe's surface (Fig.1).

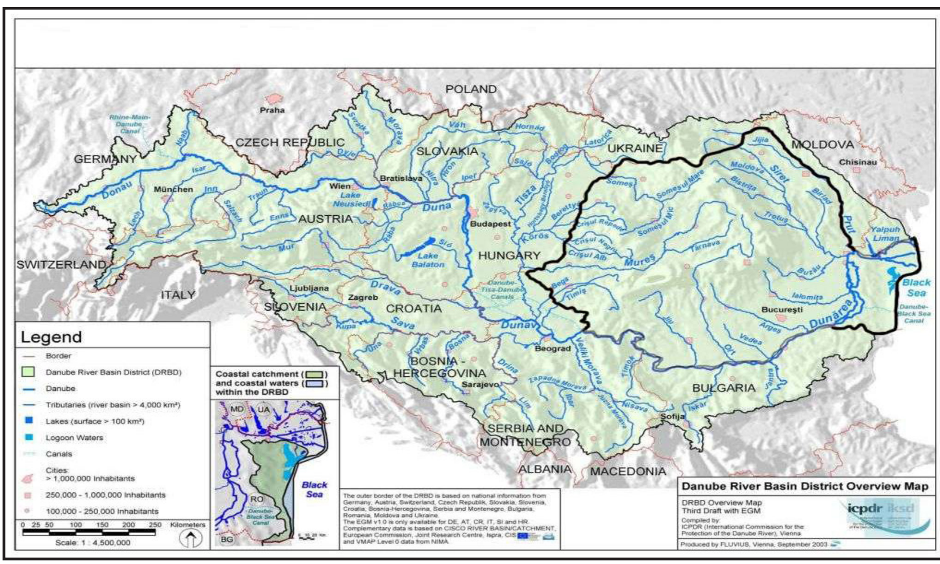

Fig. 1. Danube River Basin (ICPDR)

Before flowing into the Black Sea, the Danube through its the river basin, drains, partially and even completely territories belonging to several European countries with different physical and geographical conditions, namely: Germany, Switzerland, Austria, Czech Republic, Slovakia, Poland, Hungary, Slovenia, Italy, Croatia, Bosnia and Herzegovina, Montenegro, Serbia, Albania, Macedonia, Bulgaria, Romania, the Republic of Moldova and Ukraine. The river artery crosses four capitals – Vienna, Bratislava, Budapest and Belgrade.

Among the Danube countries, Romania occupies 28.4% of its river basin, followed by Hungary (11.4%), Austria (10%), Germany (7%), etc. It should be noted that Romania's territory is 97.8% drained by the Danube basin (Hungary 100%, Austria 96.3%, Slovakia 96%, etc.). Also, the Danube represents on certain segments the natural borders of some countries. In Romania, the Danube flows into the Black Sea on a length of 1075 km (38% of its length), partially forms borders with Serbia, Bulgaria, the Republic of Moldova and Ukraine.

The Danube River basin develops on various relief units belonging to or being adjacent to Hercynian massifs, on the one hand, and to the mountain ranges of the Alpine orogeny, on the other hand. The borders of the Danube basin pass, in the south, on the ridges of the Alps, the Dinarics and the Balkans, and in the north, over the Jura, the Bohemian Massif, the Carpathians and the Moldavian Plateau. The course of the Danube from its sources in the Black Forest Mountains to its discharge into the Black Sea, through paleogeographic evolution, was completed in the late Pliocene and early Quaternary, by successive drainage in time from the Pannonian Depression and the Getic Depression.

From the source to the outflow, the Danube alternately crosses mountains through gorges / gates, depressions and plains: Bavarian Plateau (Upper Danube Depression), Passau Gorge (flanked by Hausruck-Alps and Sumava Mountains-Bohemian Massif), Vienna Basin, Devin / Bratislava Gate (between Leitha Mountains, 484 m from the Lesser Carpathians, 768 m from the Western Carpathians), Bratislava Basin, Višegrád Gorge (between Pilis Mountains (757 m) and Börzsöny Mountains (939 m), Depression / Plain Pannonian, Iron Gates Gorge, from the South-Eastern Carpathians, the Getic Depression / Romanian Plain (Lower Danube Plain) and the Deltaic Alluvial Plain.

The characteristics of the river basin are greatly influenced by the major relief units traversed and the related climatic conditions. In terms of climate, the Danube basin is at the interference of the oceanic type in the west, with the continental to moderate to excessive in the east, sub-Mediterranean in the south and Scandinavian-Baltic in the north. At the same time, there is an altitudinal climatic stratification, marked by the thermal gap and precipitation: about 500-600 mm annually in the plains and over 1200-1400 mm on the mountain tops, in the Alps there are glaciers. The gates or gorges resulting from the penetration by epigenesis or capture (Devin, Iron Gates), delimit the ***three sectors of the Danube: upper (alpine), middle (panonic), lower (pontic)*** (P. Gâştescu, 1998).

The upper course ***(alpine sector)*** of the Danube River runs from its spring to the Devin Gate (Bratislava) with a length of 1060 km, after the union of the two tributaries of the source Brege with Brigach at Donaueschingen, to Passau where it forms a small gorge between the extensions Alps and the Bohemian Massif. Downstream of the confluence of the two tributaries (Brege and Brigach), the Danube loses underground, through the Jurassic limestones of the Jura Suabo-Franconian mountains, between Möhringen and Würtemberg, about 5 m³/s to the tributary Aach of the Neckar, remaining dry, on average 120 days in dry periods (in 1921 a particularly dry year, the Danube dried in this segment for 9 months) (Ujvari, I., 1972).

Next, the Danube enters the Bavarian Plateau where, up to Passau, it receives tributaries from the Alps-Gunz, Mindel Riss, Iller, Lech, Isar, Inn, the last confluence at Passau has the highest average flow (810 m³/s, more higher than that of the Danube (660 m³/s).

Also in this sector, from Passau to Devin Gate, the Danube flows through the Viennese Depression, the slope varies between 0.6 - 0.9 ‰, and from the northern slopes of the Alps it receives more important tributaries on Traun and Enns. After crossing the Wienerwald Mountains (Viennese Forest), the Danube enters the actual Vienna basin where the riverbed widens into meanders, with banks eroded by moraine deposits that it crosses and receives on the left the Czech Morava, which also forms the border between Austria and Slovakia about 100 km.

The middle course ***(panonic sector)*** runs to Baziaş with a length of 725 km, between the Devin Gate that separates the Alps from the Lesser Carpathians (Male Karpati) downstream of the confluence with Moravia and the Iron Gates, crossing the Pannonian Depression / Plain.. In this sector, the Danube, between the Devin Gate and the Višegrád gorge, splits into two arms forming a 90 km long island called the Inner Delta by the Slovaks, also where the rivers Vah, Hron, Ipoly on the right, and Rába on the left converge. In this sector, in Gabcikovo, in Slovakia, a hydroelectric power plant was built, much discussed from the point of view of ecological opportunity. From Višegrád, further on, the Danube crosses from north to south the actual Pannonic Depression with the Tisza Plain (Nagy Alföld) on the left. Due to the small slope (0.05 ‰), downstream of Budapest it splits into two arms forming the island of Csepel, then numerous meanders, so that before Baziaş it receives the most important tributaries Drava, Sava and Morava from Serbia, on the right, Tisza and Timiş from the left.

The lower course ***(pontic sector)***, 1075 km long from Baziaş to Black Sea forms Romania's natural border with Serbia,Bulgaria,Ukraine and Republic of Moldova. In this sector, the largest tributaries lie on the left bank in Romanian territory (Jiu,Olt, Argeș, Ialomița, Siret, Prut) and on the right bank tributaries from Serbia and Bulgaria are much smaller (Timok,Ogosta, Iskar, Vit, Iantra, Lom). Here the Danube forms the longest and beautiful gorge area-the Iron Gate

The slope of the riverbed, along the entire lower course, at an average level is 0.06 ‰ (at a level difference of 66.5 m between Baziaş and Sulina). Seen separately, in the gorge, on a distance of 144 km, at an altitude difference of 30 m, the slope is 0.20 ‰, and in the plain region, on 941 km, on an altitude gap of 36.5 m, the slope is 0.04 ‰.

In the lower course, the Danube has several subsectors, namely: the gorge at the Iron Gates, Gura Văii-Călăraşi, Călăraşi-Brăila (of the ponds), the maritime subsector from Brăila to Ceatal Chilia (Pătlăgeanca locality) and the Danube Delta.

From the 1075 km, the Danube crosses the entire Romanian territory from Silistra to the confluence with the Prut River, on a length of 205 km (km 375-170).

From Ceatal Chilia takes place the ***Danube Delta***, located on the border between the continental and marine, subject to the successive influence of one or the other and in a continuous evolutionary process, with a landscape specific to wetlands with high biodiversity.

1. 2. Hydrological characteristics

The water regime of the Danube River is characterized by important variations in level and flow during the year and over time. In spring, following the snow melting and the presence of heavy rains (level-rain supply), corresponding to the interval May-June, large spring waters are produced for the upper course, and in the middle and lower, as a result of pluvio-level supply, large waters appear in April - May. From the confluence with the Inn River to Bratislava, the Danube, after receiving some tributaries that feed from the Alps' glaciers, records high flows in June. In autumn, small autumn waters occur, especially in September and October. In winter and summer, the water regime is characterized by levels and flows with moderate values.

The average flow, as a result of the inflow, registers an increase from upstream to downstream. Thus, in the upper course it has 1470 m^3/s at Passau (the Inn is the most important tributary, having at its discharge a flow of 810 m^3/s, much higher than that of the Danube in this section, 660 m^3/s), 1920 m^3/s in Vienna and 2350 m^3/s in Budapest, in the middle course. Upstream of Baziaş, the Danube receives three important tributaries (Drava with 670 m^3/s, Tisza with 814 m^3/s and Sava with 1460 m^3/s, totaling an average flow of 2944 m^3/s) and enters Baziaş, in the Gates Gorge of Iron with an average flow of 5560 m^3/s. In the lower course, from Baziaş to Ceatal Chilia, through the contribution of tributaries from Romania, especially from Bulgaria, the average flow of the Danube to Ceatal Chilia reaches 6495 m^3/s In the Danube Delta, depending on the drainage slope and anthropic changes, especially on the arms of Sulina and Sfântu Gheorghe, the flow is distributed as follows: 58% on Chilia, 22.5% on Sfântu Gheorghe and 19.5% on Sulina (Fig. 2) (P. Gâştescu, R. Pike, 2005, Elena Ţuchiu, 2018, b).

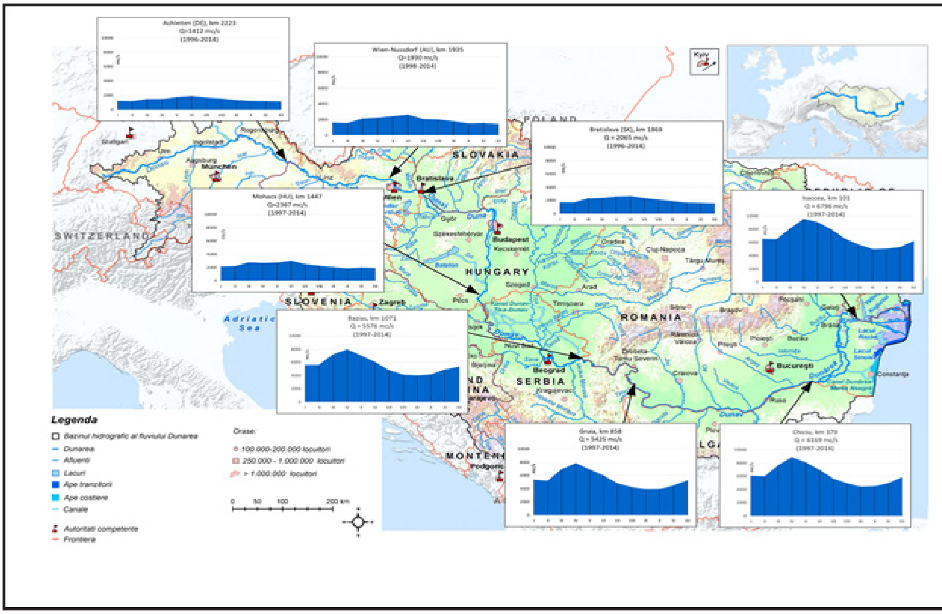

Fig. 2. Variation of multiannual monthly average discharges Of Danube River at the main hydrometric stations (Elena Ţuchiu, 2018, b)

The maximum flow is recorded during the high spring waters, but sometimes it also occurs in summer. Thus, in April 2006, the highest flows from 1931-2016 occurred, at Baziaş 15800 m³/s, at Giurgiu 16300 m³/s and at Ceatal Chilia 15900 m³/s.

The minimum flow occurs during autumn and sometimes in winter (1040 m³/s at Baziaş in 1949, 990 m³/s at Gruia in 1985 and 1790 m³/s at Ceatal Chilia in 1947) (P. Gâştescu, Elena Ţuchiu, 2012).

The solid flow was 53 million tons/year, respectively 1681 kg/s, of which 2.81 million tons/year are coarse alluvium (sands). The extreme values recorded during this period were 4470 kg/s (141 million tons/year) in 1871 and only 229 kg/s (7.2 million tons/year) in 1990. Throughout this period the trend was decreasing by a rate of 8.3 kg year, with oscillations corresponds to the variation of the liquid flow (C. Bondar, 2004).

Through the hydrotechnical works carried out for various purposes, those regarding the damming of the floodplain for flood protection were removed from the liquid flow regime in the middle-panonian sector Slovakia, Hungary, Slovenia, Croatia and Serbia, on the Danube and tributaries about 3.7 million ha. The territory of Bulgaria was dammed by about 88,000 ha of meadow on the right bank, works carried out in the 30s and 40s of the last century. The Danube floodplain on the Romanian territory, between Gruia (downstream Ostrovul Mare) – km 851 and Isaccea – km 108, 79% of the surface of about 550,000 ha was dammed.

1.3. Danube water quality

The Danube TransNational Monitoring Network (TNMN) of the International Commission for the Protection of the Danube River (ICPDR) was implemented in 1996. The Danube River water quality assessment is analyzed in terms of spatial variation (from Germany to Romania) and temporal (period 2006 – 2015, with emphasis on 2015) of the physico-chemical and biological indicators monitored in the main sections. The spatio-temporal evaluation of the Danube water quality was made for: physico-chemical indicators structured in 6 groups: general indicators, oxygen regime, nutrients, specific organic pollutants and biological indicators (Fig. 3).

Fig. 3. The Danube TransNational Monitoring Network i - TNMN (Sursa: ICPDR)

Spatial assessment of Danube water quality carried out for 2015 in 12 sections (Dillingen, Jochenstein, Wien-Nussdorf, Bratislava, Szob, Hercegszántó, Novi Sad, Baziaș, Pristol, Oltenița, Chiciu and Reni) on most physico-chemical indicators, taking into account view the values of minimum, average, maximum concentrations, 50% percentile (median) and 90% percentile (except dissolved oxygen at the 10% percentile). Chemically, the upstream-downstream spatial variation of average annual concentrations (2015) is increasing for most parameters, indicating the transport and accumulation of pollutants, but for several indicators / parameters (alkalinity, calcium, potassium, iron, nitrates, inorganic nitrogen and total nitrogen) a decreasing spatial trend was highlighted.

The evaluation of the spatio-temporal trends for 10 years (2006-2015) was done in 9 sections (Jochenstein, Hainburg, Bratislava, Szob, Hercegszántó, Borovo, Pristol, Chiciu and Reni), for 6 physico-chemical parameters (suspended solids, chlorides, CBO5, inorganic nitrogen, ortho-phosphates and total phosphorus), selected due to their relevance. Spatially, with the exception of inorganic nitrogen, which has a tendency to decrease the multiannual average concentration (2006-2015) from upstream to downstream, all other parameters have an increasing trend from Jochenstein to Reni. From a temporal point of view, there is a tendency to decrease the average annual concentrations for the period 2006-2015, especially for organic substances (CBO5) and nutrients (inorganic zot, ortho-phosphates and total phosphorus), due to improvements in Danube water quality, as an effect of pollution reduction measures, mainly (Fig. 4,5) (Elena Ţuchiu, 2018, b).

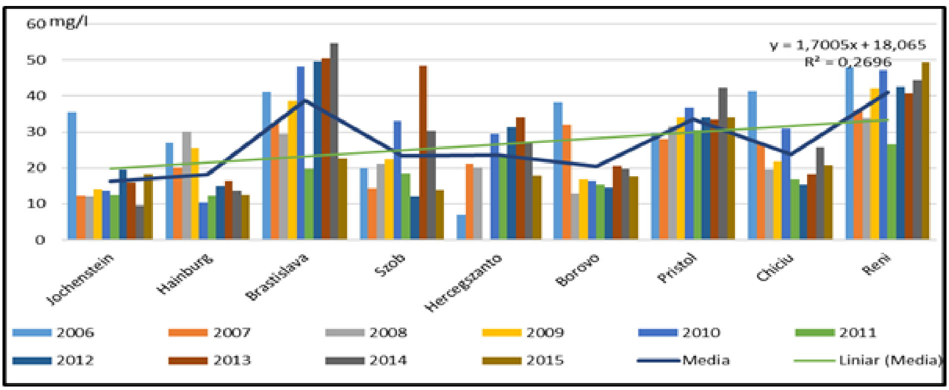

Fig.4. Average annual and multi-annual variation of concentrations of suspended solids on the Danube River (2006-2015)

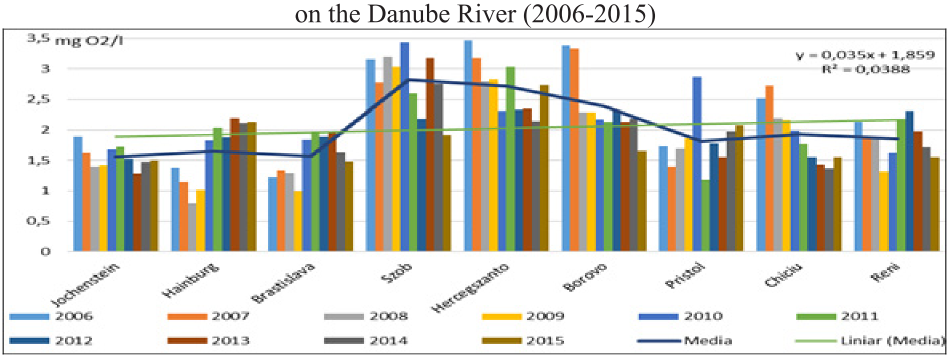

Fig.5. Annual and multi-annual variation of CBO5 concentrations on the Danube River (2006-2015)

2. CHARACTERISTICS OF THE DANUBE'S LOWER WATER COURSE (the Pontic sector)

2.1. Hydrographic characteristics

According to the morphohydrographic configuration, the minor and major riverbed is subdivided into sectors: Baziaş-Gura Văii, Gura Văii-Călăraşi, Călăraşi-Ceatal Chilia (Pătlăgeanca) to which is added the Danube Delta with its special features.

The Baziaş – Gura Văii sector, 132 km, known by the toponym Iron Gates Gorge is one of the famous gorges in Europe, in which through Cazanele Mari (3.5 km) and Cazanele Mici (5.5 km) the Danube penetrated the Carpathians. By the formation of the accumulation lake, the morphohydrographic configuration was modified, as well as the hydrological regime of the Danube, of semi-lacustrine (polydynamic) type. The hydropower and navigation system at the Iron Gates came into operation in 1971, the dam at Gura Văii has a length of 1278 m and a hydropower plant with a total installed capacity of 2100 MW.

The Gura Văii – Călăraşi sector, with a length of 566 km, the minor riverbed with widths between 500 and 1500 m is characterized by a higher degree of meandering, with more islands. The meadow is fragmentary up to Basarabi-Calafat and continues with variable widths of the order of hundreds of meters to several km. The Danube, in this sector, receives several tributaries, both from Bulgaria – Timok, Ogosta Iskar, Vit, Iantra, and from Romania – Drincea, Jiu, Olt, Vedea and Argeş. In this sector, the second dam with accumulation lake was built, at Ostrovu Mare, which came into operation in 1986, the hydropower plant having an installed capacity of 410 MW (Geography of Romania, vol. V, 2005)

In the Călăraşi – Ceatal Chilia sector (Pătlăgeanca) which takes place over a length of approx. 300 km there are two subsectors: that of Bălţii Ialomiţei - Brăilei and that of the maritime Danube Brăila-Ceatal Chilia. *Balta Brăilei and Balta Ialomiţei / Borcei* run for a length of 195 km and are delimited by two main arms of the Danube. The Balta Ialomiţa and Brăila had a special significance and importance as wetlands before damming and draining. In the maritime subsector Brăila – Ceatal Chilia (Pătlăgeanca), the average flow of the Danube, due to the waters brought by Siret and Prut, has at Ceatalul Chilia approx. 6500 m^3/s. Until Pătlăgeanca, the Danube flows through a single riverbed and creates, on the right bank, floodplain sectors in which large lake complexes have developed, which alternate with the limestone promontories, which reach the Danube riverbed (Isaccea).

The Danube Delta sector starts from the First Cetal where it Danube River into the arms of Chilia, to the north and Tulcea, to the south to the Second Ceatal, where it branches into the arms of Sfântu Gheorghe and Sulina and the Black Sea coast-deltaic front. Within the boundaries between the Chilia arm, in the north and the Tulcea and Sfântu Gheorghe arms, in the south and the Black Sea coast-deltaic front, the actual surface of the Danube Delta is 4152 km^2, of which in the most conditions is found on the territory of Romania, ie 3446 km² (82%). The Chilia arm with many branches and islands, is the youngest and longest (120 km) and carries most of the water and alluvium (58%). In its evolution it formed several secondary deltas – the first in the Pardina depression, the second after the locality Chilia Veche and the third, in progress, after the Periprava-secondary delta of Chilia, on the territory of Ukraine. The Sulina arm was preferred following the studies of the European Danube Commission (1856) for maritime navigation, which led to the correction of meanders and the deepening of the riverbed between 1862 and 1902. As a result, the length was reduced from 92 km to 63.7 and the volume of water and alluvium drained increased from 7-8% to 18.8%. The city of Sulina as a port of entry for maritime vessels has had variations in its economic development. Due to the alluvium deposited at the mouth of the arm, a channel was made that gradually advances into the sea (currently 10 km long) to protect navigation. The Sfântu Gheorghe arm, the southernmost and oldest arm with a length of 108.2 km, has also undergone changes in recent years by rectifying the meanders of six, shortening to 69.7 km. The volume of water and alluvium that flows on this arm is 23.2%.

Morphohydrographic changes evolved naturally until the second half of the nineteenth century, with the establishment of the European Danube Commission (1856) when the change was initiated, especially on the Sulina arm to make the maritime navigation channel. The creation of canals, inside the delta for the improvement of the fish potential at the initiatives of the hydrobiologist Grigore Antipa in the period 1900-1955, followed by agricultural and forestry territories, some of them being abandoned. In the configuration of the use of deltaic lands, currently are removed from the natural weighing, respectively the evolution of natural processes, 30% of the surface of the Danube Delta (Fig. 6).

Fig. 6. The morphohydrographic configuration of the Danube Delta prior to the development works (1860)

The deltaic sea shore in front of the Danube Delta and the Razim-Sinoie Lake Complex extends over a length of about 180 km, between the Gulf of Jibrieni (Ukraine) and Cape Midia, at the southern end of the Chituc Grind. The shore of the delta consists of sandy beaches of low altitude (up to + 2.7 m), subject to floods during sea storms. The mouths of the Danube tributaries are in the natural regime, except for the mouth of the Sulina canal arranged and maintained for maritime navigation in the form of an extended canal with dikes in the sea for about 10 km from the southern shoreline.

The Danube floodplain, by its size and complexity, is the most important morphohydrographic formation developed, especially on the left side, downstream of the Iron Gates Gorge. On the Romanian territory, the Danube floodplain with an area of 5500 km² (excluding the delta), through the damming action started modestly in 1904-1916 with the Chirnogi arrangement, continued with those from the Monastery, Luciu, Giurgeni and generalized in the period 1960-1990, was dammed between Gruia and Isaccea in an area of 4380 km² (79.6%) and compartmentalized into 53 modules (Ioaniţoaia et al. 2007, Mihailovici et al. 2006). If until the early 1950s, the Danube floodplain was one of the most important wetlands in Europe, with natural and semi-natural ecosystems of which about 45% were permanent aquatic ecosystems (lakes, ponds, swamps, backwaters) flooded 3-4 months / year during high seas, currently, most of them being reduced / modified. Thus, the meadow in natural conditions, fulfilled important functions such as: hydrological function, biochemical (ecotonal) function, ecological function, climatic function, socio-economic function, functions / services largely lost by carrying out dam works (The Danube – a river with green floodplains, 2002) (fig.7).

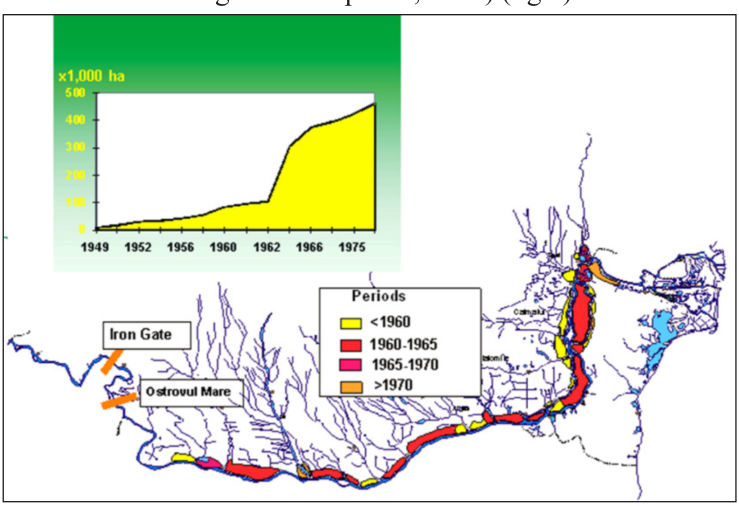

Fig.7. The evolution of the Danube floodplain dam actions
(Source: INCD Delta Dunării)

2.2. Hydrological characteristics

The hydrological regime of the Danube in the lower course is considered relatively uniform due to the ratio between the minimum flow and the maximum flow of 1/10 and which is determined by the alpine tributaries of the upper course and those of the middle course, especially Drava, Sava and Tisa, so at the entrance of the Danube in the Iron Gates gorge, at Baziaș.

From the analysis of the flows from 1931-2016, during the 1075 km of the lower Danube, there is an increase of the average multiannual flows from upstream – Baziaş (5561 m^3/s) downstream – Ceatal Chilia (6495 m^3/s), of the flows minimum flows (1040 m^3/s at Baziaş and 1790 at Ceatal Chilia) and maximum flows (15800 m^3/s at Baziaş and 15900 m^3/s at Ceatal Chilia). The maximum flow is recorded during the high spring waters, but sometimes it also occurs in summer. Thus, in April 2006, the highest flows from 1931-2016 occurred, at Baziaş 15800 m^3/s, at Giurgiu 16300 m^3/s and at Ceatal Chilia 15900 m^3/s. The minimum flow occurs during autumn and sometimes winter (1040 m^3/s at Baziaş – 1949, 990 m^3/s at Gruia – 1985 and 1790 m^3/s at Ceatal Chilia – 1947) (P. Gâştescu, Elena Ţuchiu, 2012).

Analyzing the variation of the average, maximum and minimum annual flows at the two extreme hydrometric stations, respectively Baziaş – entrance to the Iron Gates and Ceatal Chilia gorge – before the Danube Delta, the trends of these hydrological parameters in the period 1931-2016 are ascertained. The average annual flows at the Baziaş hydrometric station register a slight decreasing tendency, as it results from the polynomial analysis, unlike the Ceatal Chilia hydrometric station, where the tendency is slightly increasing (Fig. 8,9,10) (Elena Ţuchiu, 2018, b).

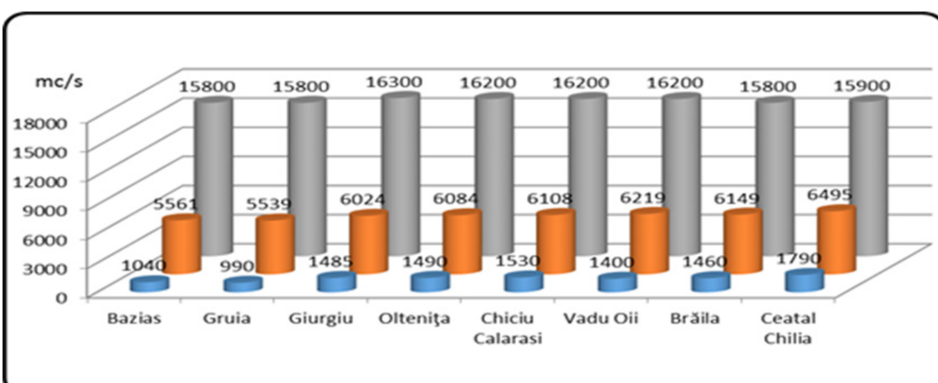

Fig. 8. Multiannual average flows, annual maximums and minimums at the main hydrometric stations (1931 – 2016)

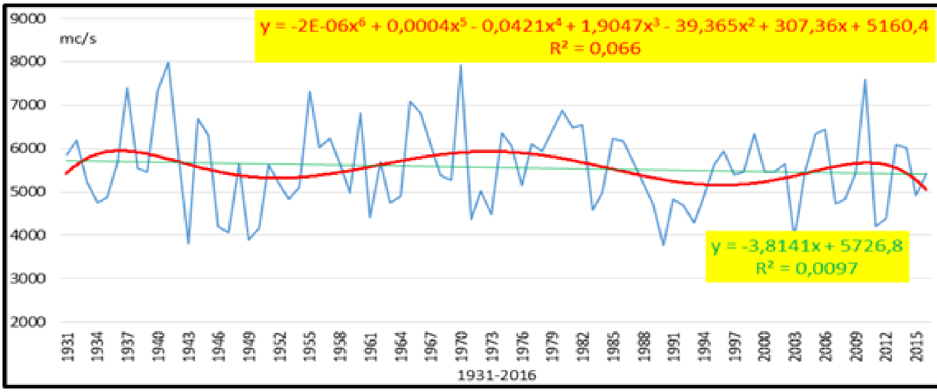

Fig.9. Variation of the average annual flow in Baziaş (the period 1931-2016)

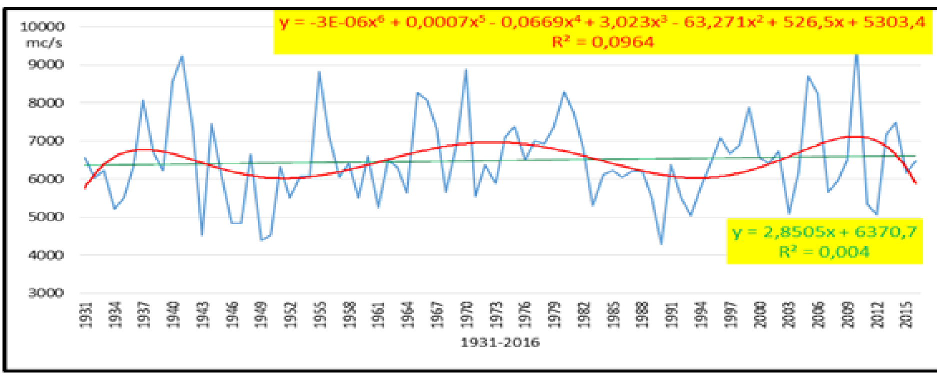

Fig.10. Variation of the average annual flow in Ceatal Chilia (the period 1931-2016)

The minimum flows are usually recorded in autumn with insurances of less than 90% due to the reduction of precipitation amounts and in winter with insurances of over 90%, due to their storage in the snow layer. The minimum annual flows in the analyzed period 1931-2016, at both stations (entrance to the gorge and delta), have tendencies of slight increase (Fig. 11,12).

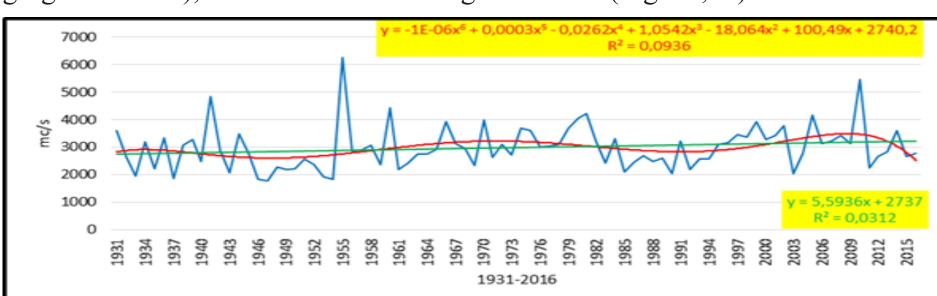

Fig. 11. Annual minimum river discharge variation in Baziaş (the period 1931-2016)

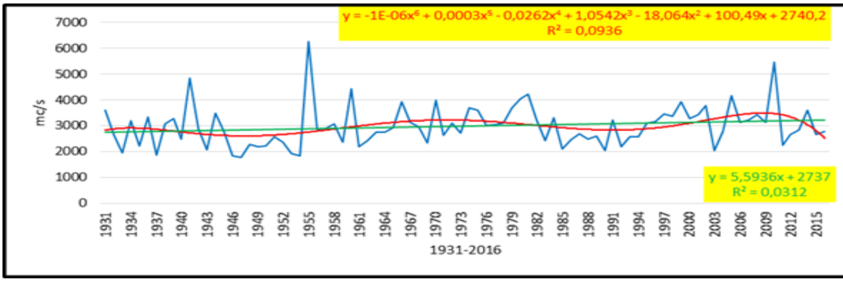

Fig. 12. Annual minimum river discharge variation in Ceatal Chilia
(the period 1931-2016)

The maximum flows usually occur in the spring-summer period, due to the overlapping effects of melting snow with spring rains on the entire basin and which generate large waters. At the Orşova hydrometric station, the first established on the Danube, in the period 1841-1965, 52 floods occurred, at a flow of > 10000 m^3/s (Danube between Baziaş and Ceatal Chilia-hydrological monograph, 1967). To these are added another 23 floods produced in the period 1968-2010, reaching 75 floods (for this period the flow from Baziaş was taken into account, because the one from Orşova was no longer representative due to the Iron Gates accumulation lake). The maximum annual flows from 1931-2016, as it results from the polynomial analysis, have a slight increase at the Baziaş hydrometric station and a significant upward trend at the Ceatal Chilia hydrometric station (Fig. 13,14).

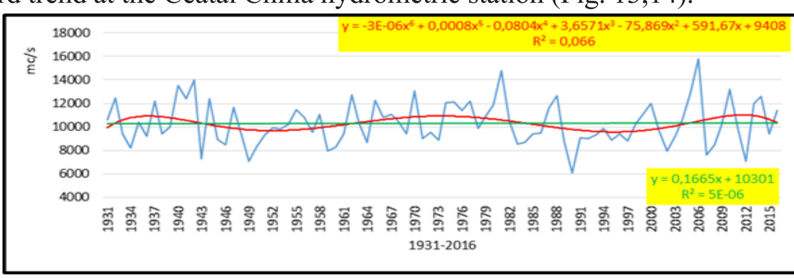

Fig. 13. Annual maximum river discharge variation in Baziaş (1931-2016)

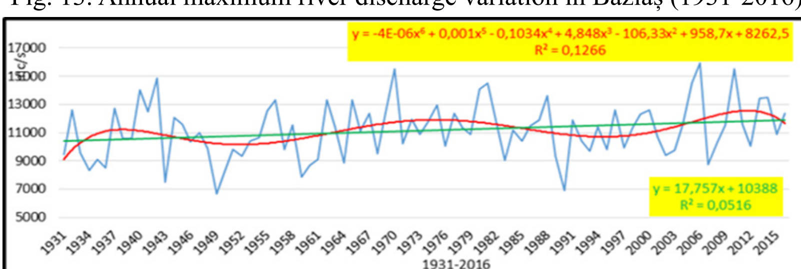

Fig. 14. Annual maximum river discharge variation in Ceatal Chilia (1931-2016)

As it results from the maximum flows, in 2006 the highest flows were registered along the entire Lower Danube (Baziaş-Ceatal Chilia) from 1931-2010, including the decade 1921-1930 and the floods produced, downstream of the accumulation lake. The Great Island.

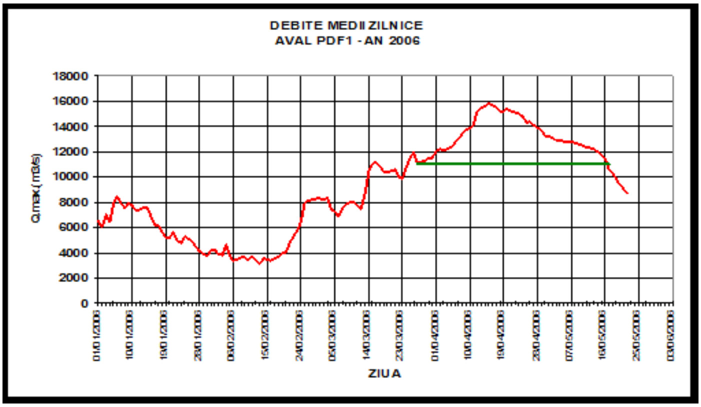

Fig. 15. Variation of the Danube flow downstream of the Iron Gates dam during the March-May 2006 flood (P. Şerban and colab., 2006),

The flood in 2006 appreciated with a probability of 1%, as flow, level and duration over the flood quota (CI) registered a maximum flow, at the entrance to the gorge at the Iron Gates of 15800 m^3/s, the highest in monitoring period 1840-2016 (Fig.15).

The magnitude of the floods associated with the floods of 2006 is compared to the floods of 1970, 1981 and 1985, produced downstream of the lake / dam at the Iron Gates. The highest flows were recorded in the Danube sector Turnu Măgurele-Olteniţa, and were gradually reduced downstream of this sector, as a result of flooding in the meadow through breaches in dams, including those caused by the authorities to avoid / defend some important localities downstream m^3/s (Brăila, Galaţi) and even from the Danube Delta.

With the exception of the flood in 2006, during the period of 170 years (1840-2010), floods with maximum flows > 15000 m^3/s also occurred in the years: 1888 (Q = 15500 m^3/s), 1895 (Q = 15900 m^3/s), 1897 (Q = 15400 m^3/s), 1940 (Q = 15100 m^3/s at Olteniţa), 1942 (Q = 15370 m^3/s at Giurgiu), 1970 (Q = 15500 m^3/s at Ceatal Chilia), 2010 (Q = 15500 m^3/s at Ceatal Chilia).

In the Danube Delta before branching, at Ceatalul Chiliei, the average multiannual flow of the Danube is estimated at 6495 m^3/s (period 1931-2016), the maximum value was registered in April 2006 (15 900 m^3/s), and the minimum in 1947 (1790 m^3/s). From the analysis of the average annual flows, for the period 1931-2016, there is a slight upward trend according to the relationship $y = 2.8505x + 6370.7$, but for shorter periods there are positive / negative variations.

The flow from Ceatalul Chiliei is distributed differently in time (monitored period) depending on the morphometric parameters of the riverbed and anthropogenic changes, on the three arms - first on Chilia and Tulcea and then on Sulina and Sfântu Gheorghe. Selecting two representative years 1910 and 1990, there is a reduction of the flow on the Chila arm (from 72% to 58%) and the increase on Sulina (from 8% to 19.5%), due to the works imposed by the maritime navigation (Fig. 16).

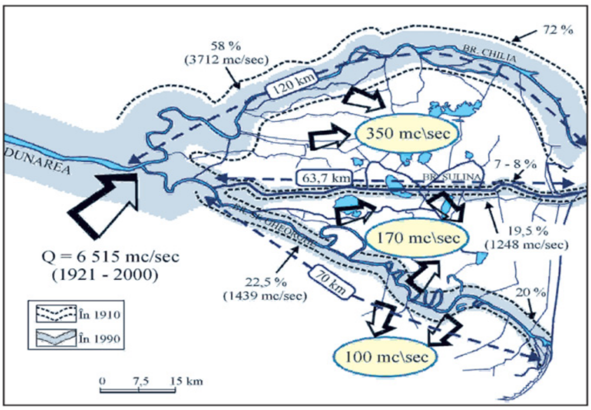

Fig. 16. Distribution of liquid flows on the arms of Chilia, Sulina and Sfântu Gheorghe

An important role in the ecological status of deltaic ecosystems is played by the liquid flow entering the lakes and canals of the lake complexes and the stagnation period during the year (Table 1).

Table 1. The liquid flows of the Danube at the entrance and exit of the delta and the main channels

Water course	Period													
	1921-1950		1951-1960		1961-1970		1971-1980		1981- 1990		1991-2000		1921-2000	
	Qm³/s	%	Qm³/s	%	Qm³/s	%	Qm³/s	%	Qm³/s	%	Qm³/s	%	Qm³/s	%
Danube entrance(A)	6 295	100	6 476	100	6 976	100	6 892	100	6 209	100	6 240	100	6495	100
Chilia	4 018	63,8	4 074	62,9	4 244	60,8	4 076	59,1	3 606	58,1	3 390	54,3	3901	60,1
Sulina	906	11,2	1 060	16,4	1 181	16,9	1 289	18,4	1 235	19,9	1 253	20,1	1154	17,8
Sf. Gheorghe	1 236	19,0	1 293	20,0	1 382	19,8	1 510	21,9	1 399	22,5	1 583	25,4	1400	21,5
Danube at spill(B)	5 986	95,1	6 215	96,0	6 657	95,4	6 534	94,8	5 589	90,0	5 702	91,4	6113	93,8
Difference A-B	- 309		- 261		- 319		- 358		- 620		-538		- 381	

The alluvium flow transported by the Danube during 1840-2010 marked a decrease due to the retention of alluvium in the accumulation lakes at the level of the drainage basin compared to the average values of 53 million t/year, respectively 1,681 kg/s, of which 2.81 million t/year represents coarse alluviums (sands) and the extreme ones of 4 470 kg/s (141 million t/year) in 1871 and only 229 kg/s (7.2 million t/year) in 1990. In this During this period, the decreasing trend was with an annual rate of 8.3 kg/year, but with oscillations corresponding to the liquid flow (Bondar et al., 1991).

In the Isaccea section, upstream of the Danube Delta, the following periods were identified: between 1900 - 1950 the annual flow of suspended alluvium decreased 1.3 times, respectively from 69.4 million t/year to 53 million t/year, the cause being the construction of accumulation lakes, especially in the upper Danube basin; between 1950 - 1980 the annual flows of suspended alluvium decreased by approx. 1.8 times, respectively from 53 million t/year to 30 million t/year due to the continuation of the accumulation lakes from the entire Danube basin, including the Iron Gates accumulation; due to the clogging of the accumulation lakes and the intensification of the erosion processes; between 2000-2010, there was an average value of suspended alluvium 20 million t/year, which still means a downward trend in solid flow, although in 2003 – a dry year – there was a value of 9.8 million t/year and in 2005 and 2006 (years with significant floods, when the Danube registered a historical value in terms of liquid flow) values of 46.4 million t/year were recorded, respectively 33.1 mil. t/year (Fig. 17).

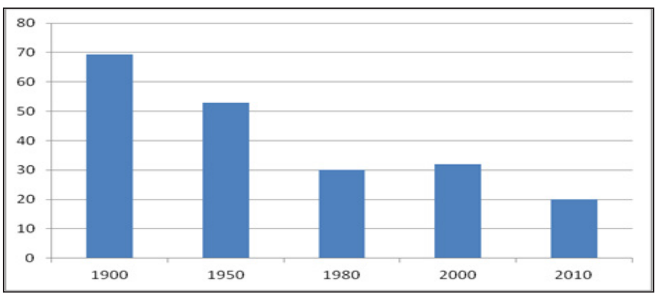

Fig. 17. Decrease in the annual flow of suspended alluvium
Transported by the Danube in the Isaccea section (mil.t/an)(INHGA)

2.3. Water quality

Water quality in the lower Danube sector was analyzed for the period 1996-2015 in the sections that are part of the Danube TransNational Monitoring Network (TNMN), of the International Commission for the Protection of the Danube River (ICPDR),

The spatial and temporal variation of the physico-chemical and biological quality indicators reflects the general characteristics (general indicators), as well as the effect / impact of the main pressures identified at the basin level: organic pollution, with nutrients and with dangerous substances. Among the general indicators were analyzed the thermal regime – water temperature, suspended solids, acidification state – pH and alkalinity, salinity – conductivity, cations – sodium, potassium, calcium and magnesium, anions – chlorides and sulfates, dissolved oxygen, organic substances measured by CBO5, CCO-Mn, CCO-Cr and total organic carbon – OCD); nutrients (ammonium, nitrates, nitrites, total nitrogen, ortho-phosphates, total dissolved phosphorus and total phosphorus), heavy metals and metalloids (iron, manganese, dissolved zinc, dissolved copper, dissolved chromium (CrIII and CrVI), Dissolved Lead, Cadmium dissolved, Dissolved Mercury, Dissolved Nickel, Dissolved Arsenic), specific organic pollutants (Phenolic Index – phenols, active anionic detergents and petroleum hydrocarbons), organic micropollutants (pesticides – pp'DDT, Lindane and Atrazine). Among the biological indicators, benthic macronevertebrates (saprob index) and phytoplankton (chlorophyll a biomass a) were considered.

Although downstream of large cities, due to the discharge of wastewater, there is an increase in pollutants, however, due to the high capacity of self-purification, in the lower course the mineralization increases slightly to 350-400 mg/l and the contribution of chlorides, sulfates, calcium and sodium. Concentrations of chemical indicators: chemical oxygen consumption (CCO-Cr), biochemical oxygen consumption (CBO5), ammonium nitrogen (N-NH4), nitrate nitrogen (N-NO3) and total phosphorus (Ptotal) for the period 1996-2015 to the sections related to the Transnational Monitoring Network (TNMN) on the Romanian sector of the Danube (Baziaș, Gruia, Pristol, Oltenița, Chiciu, Reni, Chilia, Sulina, Sf.Gheorghe) were presented as follows: from a spatial point of view they had an increasing tendency in longitudinal profile (upstream–downstream), except for ortho-phosphates which had a decreasing tendency, and the alkalinity quasi-constant; in terms of time, especially in the Reni section, the trend has been decreasing, due to the improvement of water quality due to the closure of many sources of industrial pollution, reduction of accidental pollution, construction of treatment plants for human settlements and industrial installations, application of the most good technologies in industry and practices in agriculture, the use of phosphorus-free detergents, according to the requirements of European and national legislation (Fig.18,19,20) (Elena Țuchiu, 2018, b).

Table 2. The average values of the concentrations of chemical indicators in the monitoring sections on the Danube during 1996 - 2015

Section / Indicator	Baziaş	Pristol	Am. Argeş	Chiciu	Reni	Vîlcov/ Chilia	Sulina	Sf. Gheorghe
CBO_5 (mg/l O_2)	2,44	2,13	2,85	2,32	1,96	2,07	2,28	2,10
CCO-Cr (mg/l O_2)	10,10	22,93	10,86	10,21	21,31	20,95	21,53	20,77
$N\text{-}NH_4$ (mg/l N)	0,21	0,24	0,18	0,14	0,22	0,23	0,24	0,24
$N\text{-}NO_3$ (mg/l N)	1,18	1,60	1,37	1,28	1,51	1,40	1,42	1,46
P Total (mg/l P)	0,123	0,098	0,127	0,148	0,104	0,094	0,094	0,094

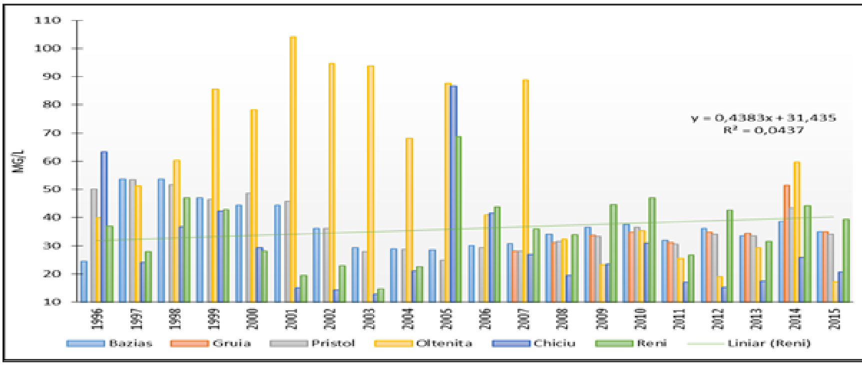

Fig. 18. Variation of average annual concentrations of suspended solids (1996-2015)

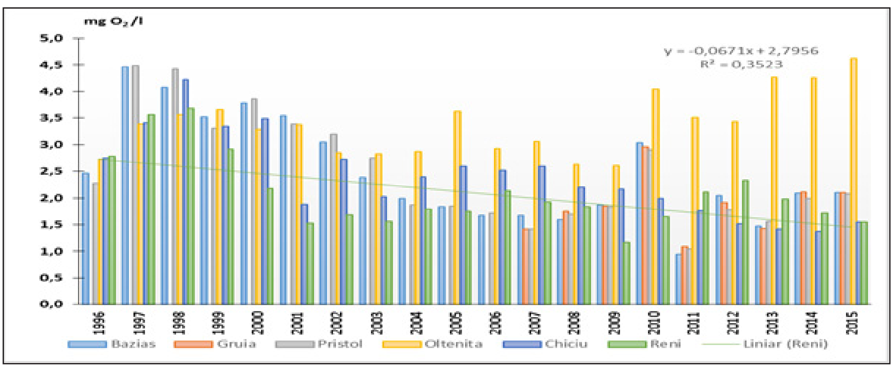

Fig. 19. Variation in mean annual values of CBO5 concentrations (1996-2015)

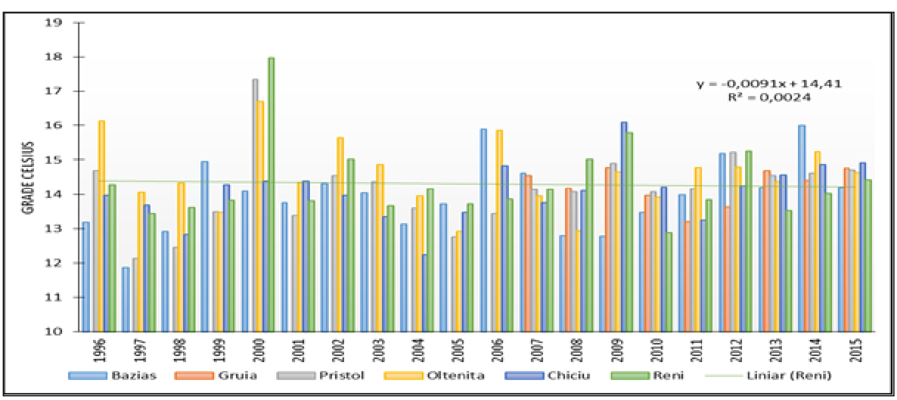

Fig. 20. Variation in mean annual water temperature (1996-2015)

3. WATER BODIES ON THE DANUBE IN PONTIC SECTOR

The typology of surface waters is a concept introduced by the Water Framework Directive which is based on criteria characteristic of natural conditions. Also, a type of surface water body (river, lake, transient water, coastal water) is an aquatic unit that has an aquatic flora and fauna determined by the climatic, lithological and morphological conditions of the minor riverbed, hydrological and physical. significant anthropogenic unmodified chemicals.

The delimitation and designation of water bodies implies their classification into 3 categories of water bodies: natural quasi-natural, strongly modified anthropically, artificial. The body of water in the case of a river represents the division of the hydrographic network into continuous and homogeneous or quasi-homogeneous elements, both from the hydrological, morphological and ecological point of view, as well as from the point of view of anthropogenic pressures and state.

The Danube typology was developed and harmonized by the GEF / UNDP Danube Regional Project, being identified and defined on the Danube between Baziaș and Isaccea 3 types (RO12 Cazane, RO13, Gura Văii – Călărași and RO14 Călărași – Isaccea). As 2 dams with accumulation lakes (Iron Gates and the Great Island) were built on the Danube, a typology of accumulation lake (ROLA03) was also defined on this sector.

On the Danube between Baziaș - Isaccea were delimited 4 anthropically modified surface water bodies, out of which 2 water bodies – rivers (Ostrovul Mare – Chiciu and Chiciu – Isaccea) and 2 water bodies – accumulation lakes (Iron Gates and Ostrovul Mare). The evaluation of the state of the water bodies on the Danube between Baziaș and Isaccea is made through the network of biological, physico-chemical elements and priority substances from 6 sections (3 profiles: left bank, right bank and middle bank) (Țuchiu Elena, 2018, b).

In the Danube Delta, on the 3 arms of the Danube River were delimited 3 surface water bodies, 2 natural water bodies (Chilia and Sfântu Gheorghe) and a strongly anthropically modified water body (Sulina). All 3 water bodies are characterized by a single typology (RO15 Isaccea-Danube Delta), and the evaluation of the state of these water bodies is based on the monitoring data provided from the 3 qualitative monitoring sections (Vâlcov-Chilia, Sulina and Sfântu Gheorghe), considering the 3 profiles defined above.

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